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DECEMBER 2002

Rock&Gem

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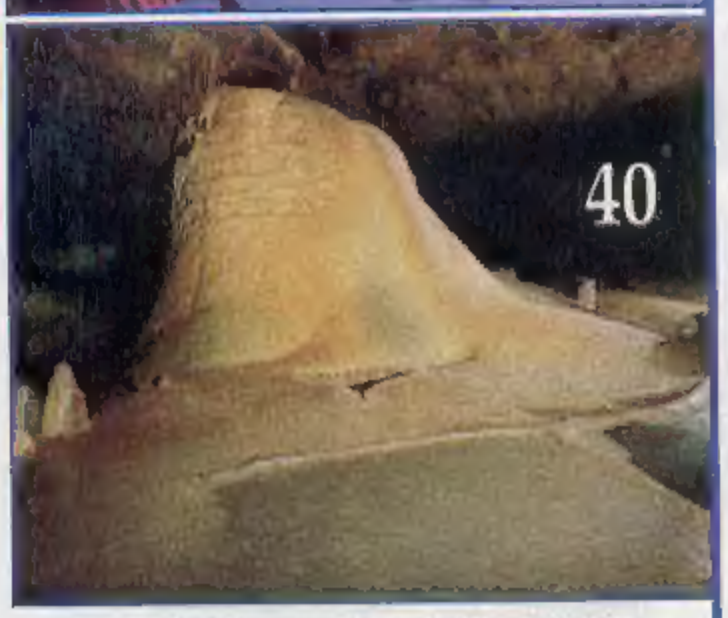

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COVER: Fine mineral specimens make a wintry scene. They are, clockwise from top, Tennessee calcite, apophyllite from India, Idaho barite, Nevada azurite, fine stibnite from China, and at center, Colorado rhodochrosite on a quartz crystal base. Specimens are from the Keith Proctor Collection, Colorado Springs, Colorado. (Photograph by Earl Lewis)

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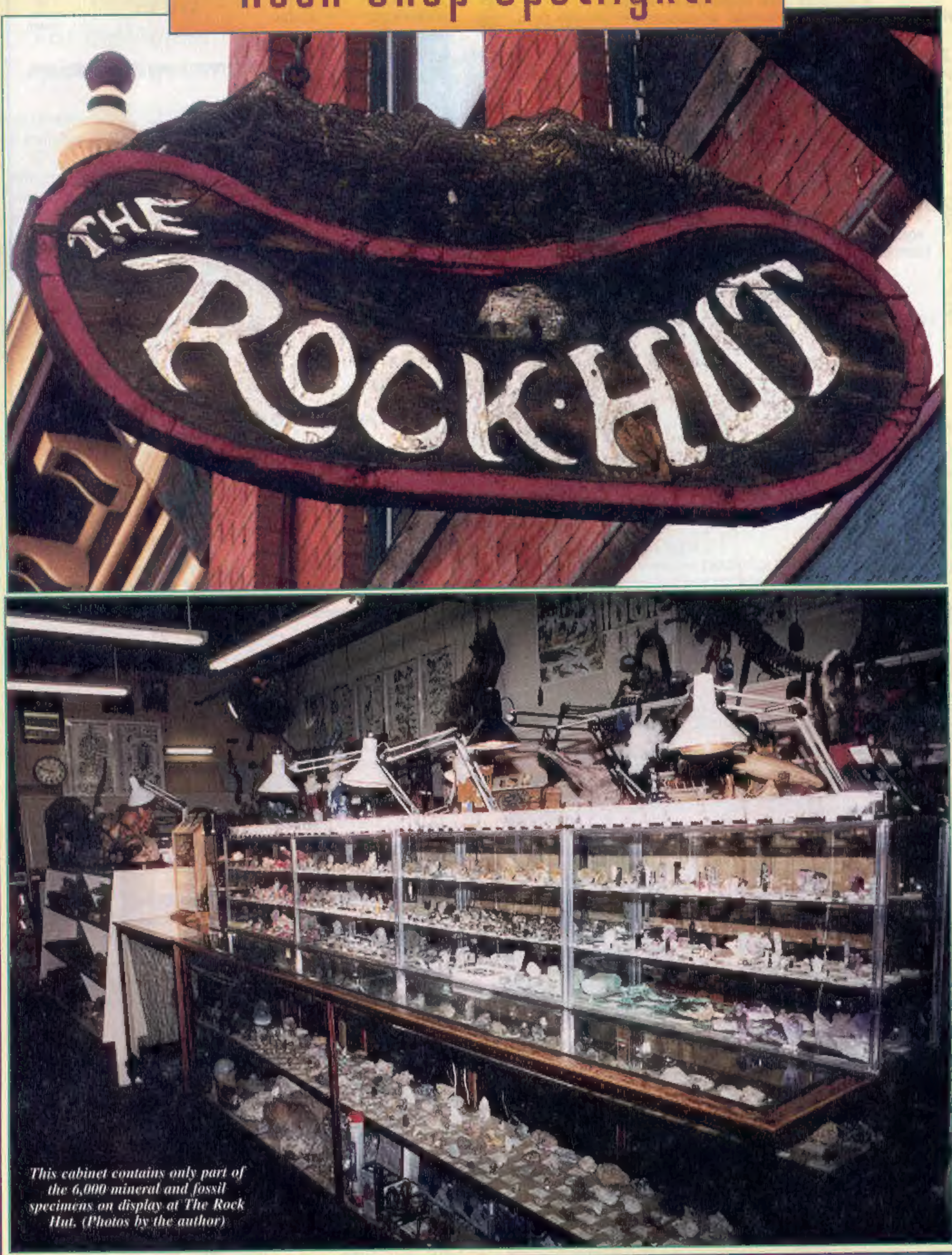

This cabinet contains only part of the 6,000 mineral and fossil specimens on display at The Rock Hut. (Photos by the author)

by Steve Voynick

Classic mining-town rock shops—shops where the minerals from local mines determine the focus of the collections—are an endangered species. Just a few decades ago, most metal-mining towns boasted at least one rock shop that bought and sold fine mineral specimens that originated, sometimes almost exclusively, in district or regional mines.

But in the early 1980s, the fortunes of the American metal-mining industry faded rapidly as the prices of silver, copper, lead, zinc, molybdenum and uranium went downhill. Today, out of every seven American underground metal mines that were producing in 1980, six have closed. And fading into history with them have gone many mining-town rock shops.

Among those that have survived, one of the best is The Rock Hut in Leadville, Colorado, a city synonymous with mining and minerals. Since the 1860s, some 500 area mines have produced more than $5 billion in metals, primarily molybdenum, gold, silver, lead and zinc.

Although Leadville's mines are now closed, visitors still flock to the 10,152-foot-high, central Colorado city in search of history and minerals. To find the history, they visit Leadville's fine museums and the ruins of its sprawling mining district. To find the minerals, they visit The Rock Hut.

Located in a 102-year-old, two-story brick building on Leadville's historic Harrison Avenue, The Rock Hut displays some 6,000 specimens. Most are from Colorado mines, in keeping with a tradition that began when The Rock Hut was founded in 1974 by Jim Witmer and the late Gus Seppi.

Gus was born in Leadville in 1914. As a teenager, he worked as an underground gold and silver miner with his father, who leased sections of old mines that dated back to Leadville's great 1880s silver boom. Over the years, Gus assembled a fine mineral collection. He later said that he learned mineral collecting from the best in the business—the high-graders of the 1930s, for whom "collecting" high-grade gold specimens during their long underground shifts was a vital supplement to otherwise meager incomes.

The Rock Hut's 100-specimen rhodochrosite display includes pieces from seven Colorado localities.

Jim and Irene Witmer have been involved with The Rock Hut since it was founded in 1974.

Gus later worked for 30 years at the nearby Climax molybdenum mine, where he met Jim. Before graduating from the Missouri School of Mines as a mining engineer in the mid-1960s, Jim worked summer jobs at Climax. In Leadville, he met his future wife, Irene, whose grandfather arrived there during the 1890s, at the tail end of the silver boom. Jim eventually became chief of engineers at Climax, heading a department of more than 100 mining engineers.

"The Rock Hut got its start when Gus retired from Climax in 1974," Jim explains. "We decided to pool our mutual interests in mining and minerals and open a rock shop that would emphasize minerals from Colorado mines—not common ores, but fine specimens of crystals and native metals."

During the 1970s, Colorado metal mining was booming, and such great districts as Leadville, Climax, Gilman, Silverton and Creede provided The Rock Hut with a steady supply of fine specimens.

"Miners brought us great material," Jim remembers, "native silver from Creede, rhodonite and native gold from Silverton, rhodochrosite and pyrite from Climax, galena and golden barite from mines here in Leadville, and sphalerite and pyrite from Gilman. We also acquired personal collections that retired Colorado miners had assembled over decades—specimens like gold tellurides from Cripple Creek and milky quartz crystals from Ouray."

When Gus passed away in 1988, The Rock Hut had already acquired tens of thousands of specimens of Colorado minerals. By then, most underground metal mines in Colorado had closed. And as the supply of new mine specimens declined, The Rock Hut's collection assumed historical significance.

Today, The Rock Hut is in its 28th year. Although The Rock Hut now displays specimens from localities around the world, owners Jim and Irene continue their traditional emphasis on Colorado minerals. And these minerals begin with rhodochrosite, which the Colorado legislature recently proclaimed the official state mineral. Half of the 100 rhodochrosite specimens on display are from such Colorado localities as the Urad, Climax and Henderson molybdenum mines, Silverton's American Tunnel and Sunnyside mines, Leadville's Julia Fisk Mine, and Alma's famed Sweet Home Mine, only 10 airline miles northeast of Leadville. Other rhodochrosites are from Peru, Japan and Mexico.

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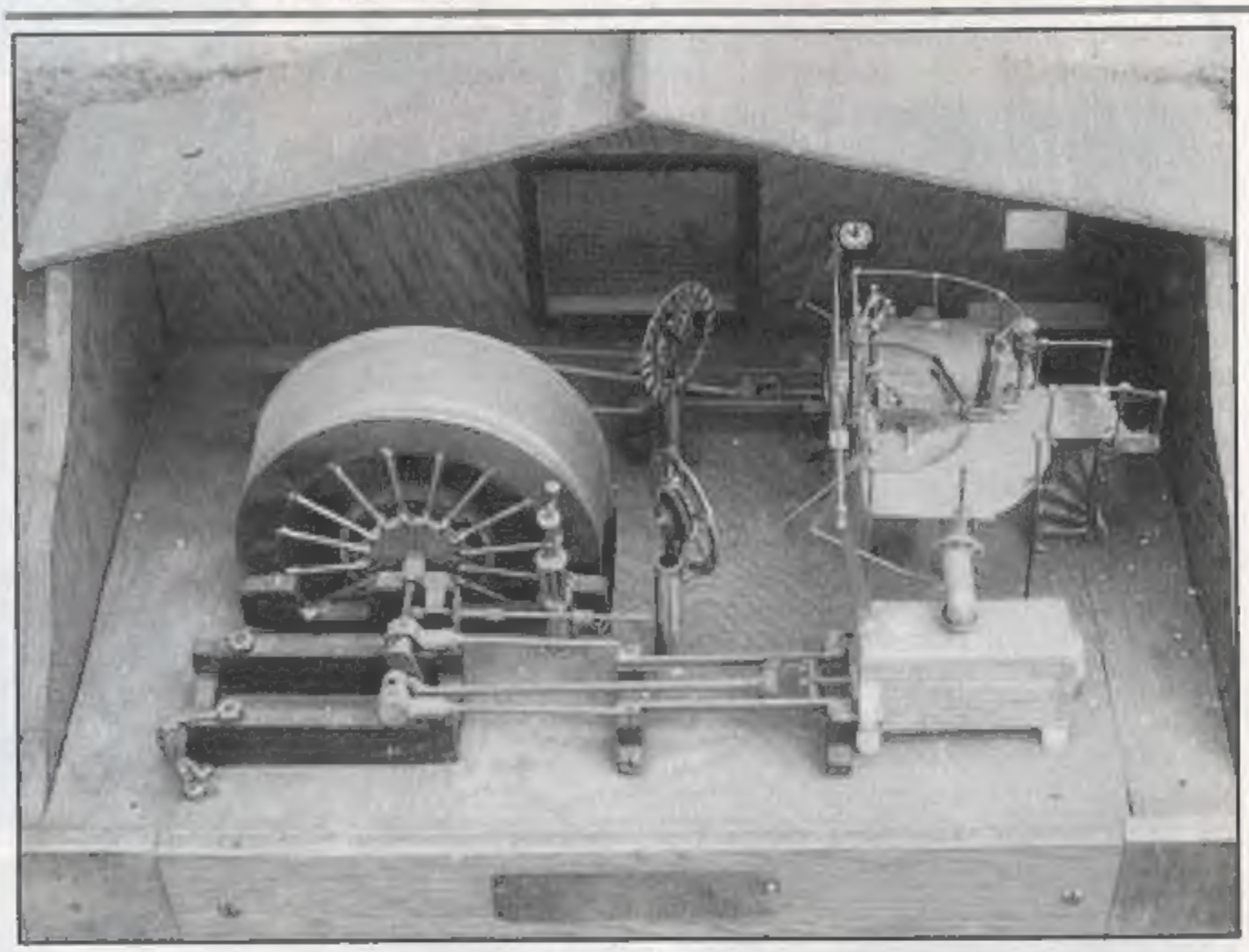


This detailed model of a steam-powered mine hoist is part of a window display at The Rock Hut.

The Rock Hut's 60-piece native gold collection includes crystallized and wire specimens from Leadville's Ibex and Black Cloud mines, Farncomb Hill at nearby Breckenridge, and the Idarado Mine near Telluride, as well as material from sites in California and New Guinea.

Another case displays gold tellurides, sylvanite and calaverite, from the famed gold-mining camp of Cripple Creek, along with "roasted" tellurides, specimens that have been heated to drive off the tellurium, leaving behind metallic gold. Complementing the gold are 30 specimens of native silver. Most are from Creede's Bulldog Mine; others are from Canada, Alaska and Mexico.

Colorado's mines have produced fine pyrite specimens, and The Rock Hut exhibits 50 superb specimens, many from the nearby Climax, Black Cloud, and Eagle mines. Leadville's Black Cloud Mine once produced superb specimens of deeply colored, transparent, golden barite and composites of snow-white dolomite on galena, both of which are included in The Rock Hut's displays.

The Rock Hut is also a place to admire Colorado gemstones, beginning with diamonds from the famed Kelsey Lake diamond mine. Other Colorado gemstone and crystal exhibits include spessartine garnets from nearby Ruby Mountain; epidote from the Calumet Mine near Salida; amethyst from La Garita; blue barite from Stoneham; green-blue amazonite and deeply-colored smoky quartz from Crystal Peak; topaz from Devil's Head; and phenakite and beautiful blue aquamarine from Mount Antero. Also on display is turquoise from the Turquoise Chief Mine, the northernmost of Colorado's five turquoise sources, which is located just four miles away.

Specimen sizes range from thumbnails and 2x2s to cabinet pieces, and prices begin at just $2 for nice Colorado thumbnails and go as high as $1,800 for killer green vivianites from Bolivia.

Fossil specimens on display at The Rock Hut number about 1,000, including many Utah trilobites and fish from Wyoming's Green River Formation. The 6,000 mineral and fossil specimens on display represent only a small part of The Rock Hut's complete collection. Virtually all the specimens, except for a handful of specimens of unusual mineralogical or historical significance that will remain in the Witmers' private collection, are for sale. Serious collectors interested in viewing the many specimens not on regular display may make special arrangements with Jim.

The Rock Hut, which lies in the heart of excellent gold-panning and mineral-collecting country, also carries a full line of prospecting supplies, from rock picks, hammers and chisels to gold pans, vials and scales.

"Much of our stock is educationally oriented and aimed at kids and earth-science teachers," says Irene. "We have everything from comparative mineral and fossil collections to science kits, books, and posters. I'm always pleased when a serious collector, a teacher, or an earth-science professional visits and reminds us that we helped fire their interest in minerals and fossils when they were young."

Filling The Rock Hut's book section are all the popular mineral and fossil magazines, along with some 200 titles of books dealing with geology, paleontology, field mineral collecting, crystals, and mining history. Jim and Irene also carry an extensive line of jewelry, notably Southwestern-style turquoise-in-silver, Black Hills gold, and Baltic amber. Other items include pewter figurines and stone carvings.

And Jim and Irene have not forgotten Leadville's rich mining heritage. One of their window displays is a collection of historically accurate, detailed models of steam-powered mine hoists fashioned from brass and copper by Leadville craftsman Bill Nelson. Also available at The Rock Hut are pen-and-ink prints of historic area mines by noted Leadville artist Bill Harrington.

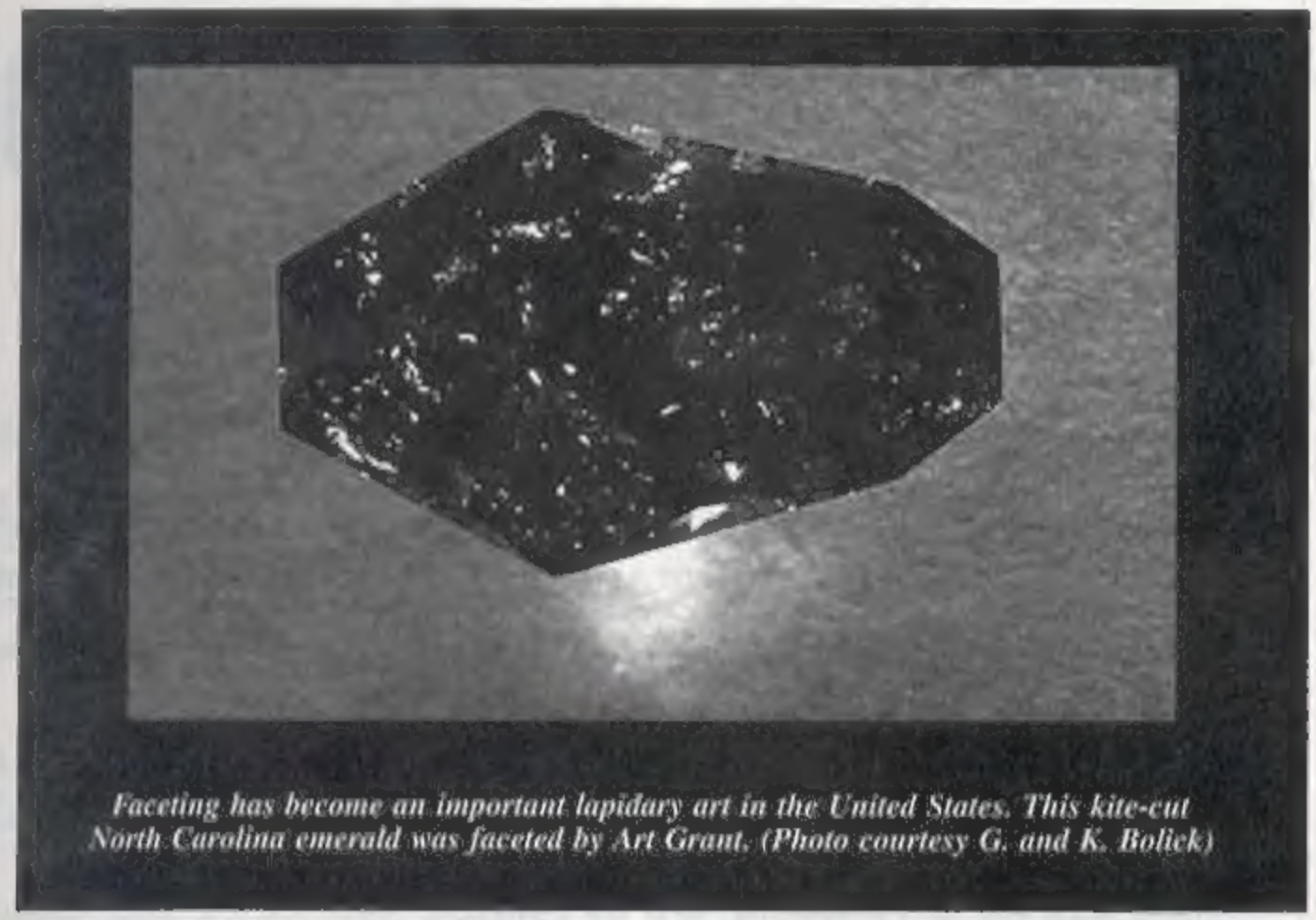
Anyone looking for a classic mining-town rock shop with mineral specimens not likely to be found elsewhere will enjoy a visit to Leadville's The Rock Hut. Open seven days a week, it's closed only on Thanksgiving, Christmas, Easter, and on the first weekend in August when Leadville celebrates its annual Boom Days summer festival. The Rock Hut is located at 706 Harrison Ave., Leadville, CO 80461. For information or directions, call (719) 486-2313.

The Rock Hut occupies this two-story, 102-year-old brick building on Leadville's historic Harrison Avenue.

LAPIDARY LORE and MORE

by June Culp Zeitner

Spotlight on Faceting



Faceting has become an important lapidary art in the United States. This kite-cut North Carolina emerald was faceted by Art Grant. (Photo courtesy G. and K. Bolick)

I first met John Sinkankas and his extraordinary helpmate, Marjorie, at a Midwest Federation banquet in the 1960s. Anyone who has heard John speak knows that his talks were as interesting and informative as his writing. And anyone who has seen his watercolors knows these are of museum class, as well as his remarkable lapidary work.

I was in awe of John when I first met him because his *Gemstones of North America* had made my life so much more pleasant and rewarding. My husband and I had started our 30 years of travel to gem and mineral locations in 1950 when there were few leads about gem deposits in America. John's book introduced us to more gems than we could prospect for the rest of our lives. I eagerly bought each of his books as they continued to dominate our market. I met John and Marjorie at numerous shows and corresponded with him on occasion. He was of immense help to me in my work on *Gem and Lapidary Materials*. I especially treasure his inscriptions in several books he autographed for me.

It is literally amazing how thoroughly John covered the field of minerals, gems and lapidary. His two-volume *Gemology: An Annotated Bibliography* is without peer. His translation from the German of Humboldt's *Travel in Siberia (1837-1842)* is an exciting contribution to gem history. Along with other gem and lapidary enthusiasts, I consider John's work the most important in our field.

When I heard of John's death I thought, "How will we gem and lapidary enthusiasts get along without him?" Then I realized that it is because of him that we will continue to progress. John was an inspiration, a guide, a mentor and a teacher. I will never see a new gem cut without thinking of him.

It is because of John's place as the dean of American faceters that this month's lapidary history will be about faceting.

* * *

John was a superb faceter. His faceted 7,000-carat quartz egg is a Smithsonian feature. He was the pioneer faceter of stones previously thought to be too large to facet.

* * *

Faceting in America is a comparatively new art. In 1915, a geologist named Brose had several fine, large Arizona garnets. He saw a display of faceted stones in a jewelry store window in Los Angeles where a sign read: "We do our own gem cutting!" He told the owner he'd like to have the garnets faceted. The reply was, "We can't do that here, but we can send them to a man in New York who will send them to Germany to be cut."

* * *

Rocks and Minerals published J. H. Howard's monograph "The Working of Semi-Precious Stones" in 1931. It had a short and rudimentary section on faceting.

In 1948, author Dr. Daniel Willems wrote about learning to facet by cutting potatoes. In the late '40s, Glen Vargas became an expert faceter and soon, with his wife, Martha, started teaching faceting classes in California. A series on facet designs was published by Steele and Long, and Tom Barbour cut quartz replicas of the world's most famous diamonds.

In the early 1950s, Lee Lapidary and MD Taylor advertised faceting equipment. Sapphire was also an early favorite. Hillquist came out with a faceting machine. A few dealers started advertising faceting rough. Some clubs emphasized faceting. The growth of lapidary clubs brought a big demand for new machines, new materials, and new cuts. The demands were met, and faceting took over as a new American art. Now we have state faceting guilds, a U.S. Faceter's Guild, and some of the world's most innovative faceters.

* * *

Nitrobenzene is sometimes used in the preparation of star stones. It is toxic and can be absorbed by the skin. Some people use oil to find the best star. A friend recommends a drop of Karo syrup. Probably the best way is to learn to find the star by examining the stone in a dim room under a single lightbulb. Note the most chatoyant area, then round it off and polish it. Return to the lightbulb and mark the spot where two legs cross. The stone should be cut with this spot on top.

* * *

Templates now have many shapes for those who think they can't draw. To design your own stone for a certain piece of gem material, combine the parts you need of two or more templates. For example, a square and a baguette could be combined or a hexagon and two triangles. Curves are now used with straight lines for countless creative shapes. Using standard cuts for cabs or facets is fine, but inventing new cuts spurs originality.

* * *

Many jewelry artists currently prefer silicones that cure at room temperature to latex for making molds for casting. Silicones are resistant to temperature change and some chemicals, and make releasing the mold easy.

* * *

When stone and metal are polished together as in channel work, cerium oxide works well on both stone and metal.

* * *

Russian scientists have made a synthetic stone that has the same rich blue as tanzanite, the popular zoisite from Tanzania. Several fine gems were discovered in Tanzania since the beginning of the 1960s. Tsavorite, a green grossular garnet, is a favorite of those who like green gems. Other gems include ruby and sapphire, green apatite, gold chrysoberyl, chrome tourmaline, phenakite, and kornerupine. New gems and new locations bring continuing excitement to lapidaries.

FIELD TRIP

Nuts About Nut Mountain

Tracking Down a Historical Mineral Oddity

Good enough to eat? Not really. Although they fooled the author and the pioneers, these smooth stones aren't petrified fruits and nuts. They are rhyolite rounds. (Photos by the author)

Gravel beds like this one often hold rhyolite nuts, whose rounded shapes are distinctive among the sharp gravel. Previous visitors left their trash, which we packed out.

by Mary E. Garatti

A dust devil materialized 80 feet from where I stood. Its slender plume of desert dust fitfully bobbed and weaved before finally dancing its way through the sagebrush. It moved as gracefully as Fred and Ginger might have done 50 years ago. And for the third time in as many minutes, a horny toad hurried past the toes of my boots as it sought the cool and protective shade of a gray-green patchwork of sage. In that brief flurry of high-desert activity, I felt as if I had been abandoned by time and civilization—a rather pleasant sensation when administered in small doses.

Now, though, the dust devil had dissolved, the horny toad had moved to an ambush spot awaiting the arrival of a plump, juicy ant for breakfast, and I looked up and around. I spotted Sandy, my rockhounding partner. She was bending over to pick up something. I had a good idea what it was, a rhyolite "nut." It was Memorial Day 2002. Sandy and I had already paid our respects at the Cedarville Cemetery. The latter part of the morning found us craning our necks and straining our eyes as we searched for the elusive nuts.

Everything is sharp in this part of northwestern Nevada, from the spines on the lizards to the obsidian flakes that lie scattered across the sagebrush flats. Spotting the smooth, rounded forms of the nuts wasn't difficult, just time-consuming. They aren't large, some of them being no bigger than a juniper berry. And when either of us found a nut, we only picked up every third one, choosing to leave some for other people and for other days. How we came to this location seeking these nuts is a story involving four states, three years, two curious people, and one uneducated, albeit avid, rockhound.

It all started when I was in Nampa, Idaho, in May 1999. I stepped into a used bookstore, arriving just before closing time. I quickly asked the proprietor to direct me to the section on California. I hoped to find a book or two I could add to my California history collection. Immediately, my eyes were drawn to the large letters on the spine of a two-tone book: *California Northeast*. The price was $50. I'm more accustomed to paying 50 cents for a used book; I do most of my book-buying at yard sales. This book, however, was published in 1951 and was a first edition of only 750 copies! I had to buy it.

continued on page 30

Nuts About Nut Mountain *from page 28*

When I returned to my Northern California home a week later, I started reading my expensive book. On page 202, a few sentences mentioned pioneers of 1849 and subsequent years rounding the base of a mountain in northwestern Nevada as they made their way to California. Rounding the base of a Nevada mountain in 1849 was nothing unusual, but one particular mountain had strange stones widely scattered around its base. The stones resembled nuts. Some of them actually looked more like small fruits. The book's author, William S. Brown, stated that the pioneers gathered some of the petrified nuts and fruits as curiosities. So intrigued were they by these nuts that the '49ers dubbed the otherwise nondescript mountain Nut Mountain. The name stuck.

I read that paragraph in the book repeatedly, wondering why I had never seen nor heard of these nuts despite my previous travels through that portion of Nevada. I must admit the brief mention of the mountain had me spellbound. One way or another, I had to learn more about Nut Mountain, Nevada.

A member of two gem and mineral clubs, I inquired about the mountain and the nuts at the next couple of monthly meetings. No one had heard of them. I began to do research on the Internet, learning only that a USGS topographical map of that quadrangle was called "Nut Mountain." At least that made it official; an agency of the federal government acknowledged the mountain. Still, how to recognize that special mountain out in an area where all the mountains looked alike was proving to be a challenging task.

Finally, I studied every map I had that covered that part of Nevada. An auto club map was especially useful. It indicated the mountain and enabled me to calculate its distance from the nearest road, approximately three miles. Still, some confusion set in when one map book appeared to name the same peak North Coyote Mountain. A third map showed a spring where the mountain should have been, but no mountain. I was frustrated, but I wasn't about to abandon my desire to explore the mountain and to collect some of the nuts.

In May 2000, I made my annual pilgrimage to Cedarville, a tiny town on the northwestern fringe of California. It is located in lovely Surprise Valley, which is literally squeezed between a rock and a hard place. I like to stay at the Sunrise Motel when in Cedarville. The fact is, I have stayed there so often that the owners, Susie and John Bunyard, recognize me as one of their regulars. They know I'm a rockhound, among other things, so Susie showed me an unusual stone one of her recent guests had given her. The thing looked very much like a petrified acorn. It occurred to me that it resembled a nut!

The actual peak of Nut Mountain still has not been pinpointed, but the nuts are plentiful on the high-desert landscape of northwestern Nevada.

I asked her if she knew where her guest had found it. Susie said he had told her it was lying beside the road about 35 miles from where we stood talking. In fact, she stated that he had gathered several of them and that each one had been found near the roadway. Excited by this new and unexpected information, I made a dash for my truck and headed toward Nevada along 35 miles of dusty road. At that moment, the words "several" and "near the roadway" were all the facts I thought I needed.

Every few miles past the 30-mile mark on my truck's trip meter, I got out and looked for anything resembling an acorn or a nut or a small fruit. I did this for a couple hours on both sides of the road, but without success. Perhaps Susie could give me more information. Back at the motel, I picked her memory and then started picking away at John's. One of them, I hoped, would give me the extra little bit of information that would finally lead me to nuts and/or Nut Mountain. They showed me Painted Point and Massacre Lake on one of my maps to use as landmarks. They said their guest had found the stones somewhere along state Route 8A, between the landmarks and the 6,920-foot peak indicated on another map as Nut Mountain. I knew I had already searched the area as well as possible with the information I had. I wasn't going back out there until or unless I had more details. Nut Mountain was relegated to the back of my mind until September of that same year.

September is a spectacular time to visit Surprise Valley. The trees and shrubs are donning their autumnal colors of garnet and gold. The air is as crisp as a ripe fall apple, and the sky is usually a deep turquoise blue. By then, the wind has mellowed into a pleasant breeze. I called Susie to make reservations for mid-September 2000. I asked her if she knew someone who could guide me to the intriguing mountain. No doubt about it, I was going nuts over Nut Mountain. Susie said she'd have to think about it, but she'd have someone for me when I arrived in three weeks.

As promised, Susie had found a guide for me. Louie was a cowboy, a real one. He knew northwestern Nevada as well as he knew how to rope and brand a calf. I drove, while Louie talked. He told me about the history, flora, fauna, weather and legends of the region. We took a couple side roads so he could show me a good campsite and the place where the grass stays green throughout the summer months. Then he had me stop on a straight stretch of road and park on the shoulder. "This," Louie said, "is where to look for nuts." He found one almost immediately upon stepping out of my truck, and he handed it to me. I found nothing.

Louie and I said very little on our return trip to Cedarville. I was pondering the nut he had found. I wanted to keep it, but I felt I should give it back to him. He, after all, had found it. Keeping it just didn't seem right to me. As I was about to offer the nut back to Louie with my sincere thanks, he spoke.

"You know," he started, "most people look at this land and consider it 'the middle of nowhere,' whereas I look at it and consider it 'the middle of everywhere.'" I didn't know if Louie had coined that phrase himself or if he had picked it up somewhere along the trail. I did know he

meant it, and I was beginning to agree with his assessment. We didn't speak again until I let him off at his truck. I thanked him and told him I was going back out there right after a quick meal and a brief nap. We parted. I had forgotten to return the nut to him. Though I didn't know him well, I did know he wouldn't care.

With the nut planted tightly in my palm as a sample of what to look for, I returned to the spot Louie had steered me earlier in the day. I looked up one side of the gravel road and down the other, then something in the gravel seemed unusual, out of place. Sure enough, it was a nut. I had finally found one. Once I found that first one, several others became apparent. At long last, after much research and effort, and with Louie's great help, I had found some of the odd stones for myself.

Unable to visit northwest Nevada the entire year of 2001, I had to settle for merely talking about it. I told my rockhounding partner, Sandy Thuet, about Nevada and the area around Nut Mountain ad nauseum. I think what finally convinced her to join me on a trip to the area was the premise that where there were petrified nuts and fruits, there had to be petrified trees. So in May 2002, Sandy and I agreed to travel there together for a rock-collecting field trip. Sandy is a knowledgeable and experienced collector and lapidary. My own ability to identify rocks and minerals is sorely lacking. I am merely an acquirer, a casual collector. If a rock appeals to me, I pick it up. I have some beautiful specimens throughout my home, but I really couldn't identify many of them.

Sandy and I arrived in Cedarville late in May 2002. Sandy pulled her trailer into the RV portion of Susie and John's property. She and I planned on visiting many sites in the area, but our intention was to focus on locating Nut Mountain itself and to collect as many of the odd little stones as ethics and good sense would allow. Our ultimate goal was to find their source.

First, though, Sandy and I decided to visit Hi Desert Craft Rock Shop in Lakeview, Oregon. While there, we told Jo Ann, owner of the well-supplied and neatly organized shop, about our plan. Jo Ann told us that she and her late husband had collected some of the nuts years ago. She said sometimes a pocket of the stones could be found. She also said the round stones were composed of rhyolite and were not at all petrified nuts. Sandy gave me an I-knew-it-couldn't-be-true look. I felt my credibility slipping as Jo Ann spoke.

continued on next page

Nuts About Nut Mountain *from page 31*

It is legal to collect the nuts on Bureau of Land Management land; no permit is required.

She told us the nuts were made during a volcanic eruption. The material, rhyolite, is a silica, similar to obsidian. It cooled more slowly than obsidian, and as it cooled a microscopic crystalline structure was created. Thanks to Jo Ann, we now knew the real story behind the nuts. (Later I learned their round shapes and smooth surfaces were formed when they were still molten and hurled through the air in the violence of an eruption.) Undaunted, we decided to look for them regardless of their true character. Sandy and I, in fact, were spurred on by even greater curiosity, our only real disappointment being the realization there would be no petrified trees.

So here we were, parked along state Route 8A in the high desert of Washoe County, Nevada, looking for "nuts" on Memorial Day, 2002. A Bureau of Land Management (BLM) ranger happened along and asked if we needed help. "Yes," I answered through the brush, "but not the kind you probably think." I told the ranger we needed help pinpointing Nut Mountain among the several peaks that rose to the south, and we needed help finding an abundant source of nuts.

As for the first request, he couldn't really help us. He said the mountain was part of a ranch, and just which peak it was had him stumped, too. As for the nuts, he told us he had found them "all over" and that we should concentrate on looking in cleared areas. He told us roadbeds were good places to investigate. We thanked him and he left us to continue our search. We hoped to find a cache of them. We didn't. What we did find, however, was the key to locating several of the widely distributed stones. The key is gravel.

Look for the nuts in areas of exposed gravel. The naturally occurring gravel has a generally rough surface and pointed shape to it. The nuts will stand out against this background since they are unusually smooth and round. Once you have found your first one, the others will be easy to spot. Dry washes, roadbeds, and areas that have been cleared by heavy equipment are good areas to search. Look in the center as well as on the sides of any jeep trails in the area, but please don't trespass. There are plenty of public acres to search without the need to access private property. The BLM office in Cedarville offers maps of the area.

From Cedarville, California, go due east on state Route 299. At the Nevada state line, the road will change from pavement to gravel and take you through '49 Pass. This road, state Route 8A, is well maintained most of the year, but it is not maintained in winter. And don't travel on it during a severe storm despite the time of year. At 21.5 miles from Cedarville, an intersection directs travelers north to Vya, east to Denio, south to Gerlach, or west and back to Cedarville. Stay on state Route 8A and head east toward Denio, Nevada. Travel another 20.2 miles to the collecting area. Along the way you will notice unmistakable Painted Point on the north side of state Route 8A. Just east of the point is a series of lakes, the largest of which is Massacre Lake. Also, sprinkled along the route are several windmills that provide water for livestock. If you see these sights, you know you are on the right road.

The collecting area is composed of several hundreds of BLM acres. Be sure to park off the road before you begin searching. It is legal to collect the nuts on BLM land; no permit is required. The ranger told us to be sure to fill in any holes we might dig in our quest to fill our bags. Experienced and considerate rockhounds know this, but it is a good thing to remember. Also, in this same large portion of Nevada can be found fist-size black obsidian chunks. The obsidian is high-quality, and Sandy says that it cuts and polishes well.

If you ever get the opportunity to visit Cedarville, California, or northwestern Nevada, don't forget to plan a trip to the Nut Mountain area. Take plenty of drinking water, wear a broad-brimmed hat, and spread on the sunscreen. With a little luck and some attention to detail, you, too, may become nuts about Nut Mountain! As for me, I'm registering in a geology class as soon as possible.

PANNING ALONG U.S. HIGHWAY 101

20 West Coast Sites to Search for Gold and Gemstones

by David and Clois Walker

Remarkably enough, few if any of the state-by-state *Roadside Geology* series have included panning potentials. Most of the various routes refer instead to highway embankment prospects or off-highway areas reached via temporary detours from the main routes.

This article, contrarily, has to do with highway/stream crossings only—and only those where minerals and gem deposits have been previously reported within appreciable distances upstream. The nature and extent of minerals and gems found, too, is narrowed to the varieties most sought after by lapidaries or others interested in deriving a little recompense now and then, to offset all those infringements on the family budget.

The U S Highway 01 route from Northern California north through Oregon and most of Washington was selected on the basis of the latest traffic surveys, which indicates its popularity with tourists in both mountainous and Pacific coastal areas As Jack would have it the same areas are particularly interesting to mineral and gem collectors, as testified to in a number of geological publications and location guide books

The states traversed by U S Highway 101 all abound in both drainage and road systems, so it was simple enough to plot the location of known mineral-bearing gravels on topographic or shaded relief maps as a forerunner to tracing their natural erosive course downstream to the U S Highway 101 intersections

The following list then, indicates the location of each of the sites suggested for exploration, together with the corresponding minerals and gems that may be found, consistent with reports by others and of the further premise of erosive concepts primarily having to do with the nature and extent of the watersheds involved, coincident with historic runoff

The convenience of access right there within prescribed rights-of way can scarcely be over emphasized particularly in view of the otherwise necessity of locating and negotiating terms and conditions with private land ormine owners, lest trespass penalties be imposed!

You should also remember the on-going safety and environmental standards being looked out for by the local patrolman, who is particularly irked—and understandably so—by illegal parking or digging in highway embankments Generally, however, a wave and a smile are contagious enough, and who knows, he may even be something of a rockhound himself!

We would suggest one additional precaution Beware of gemologists

LOCATION AND VICINITY FINDS ALONG U.S. HIGHWAY 101 (NORTHERN CALIFORNIA, OREGON, WASHINGTON)

CALIFORNIA

Sonoma County (Map CA-1)

Site 1 Crossing on the Laguna de Santa Rosa near SANTA ROSA Vicinity finds include jasper and silicified wood

Site 2 Crossing on Mark West Creek near FULTON Vicinity finds include jasper and silicified wood

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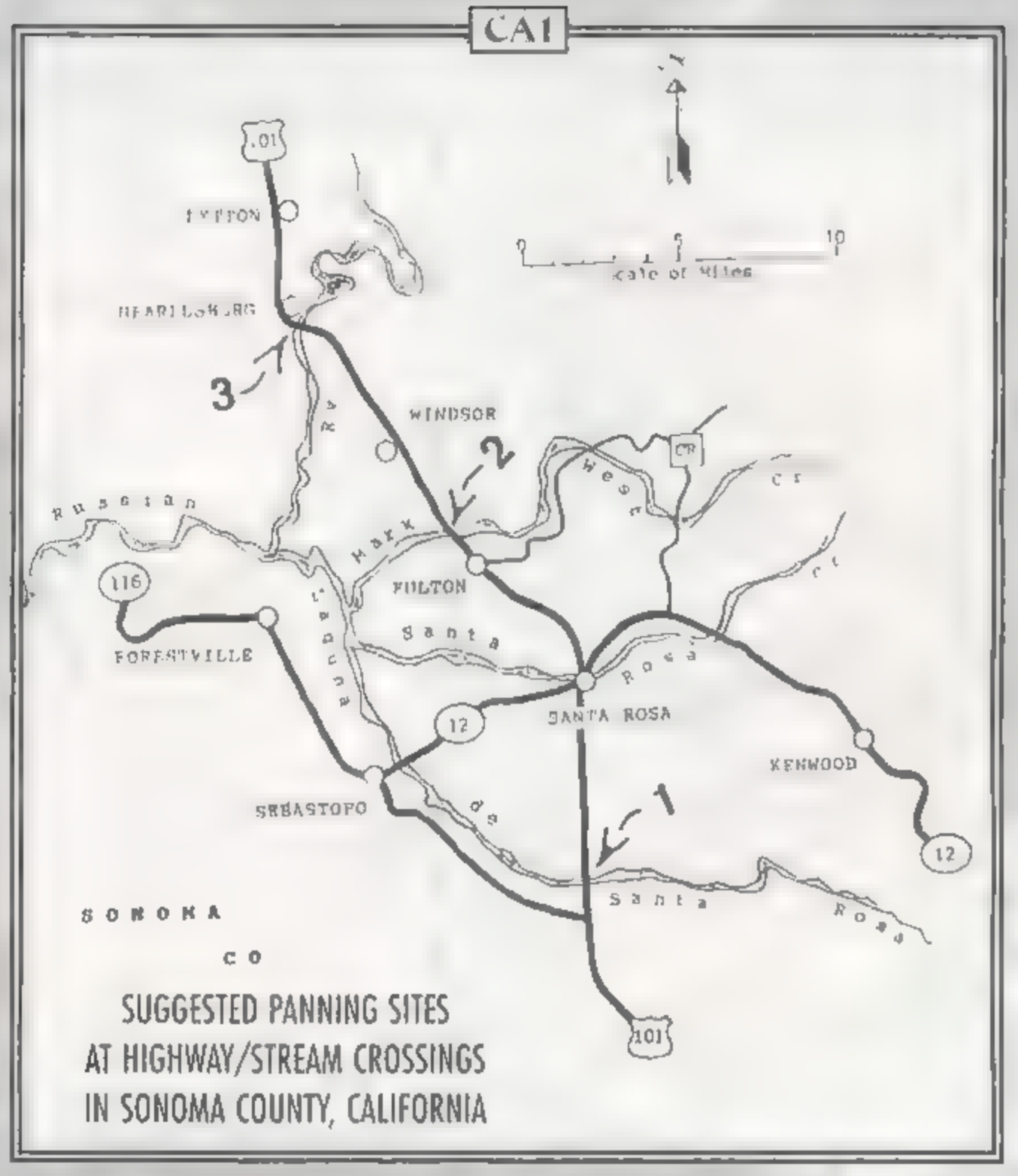

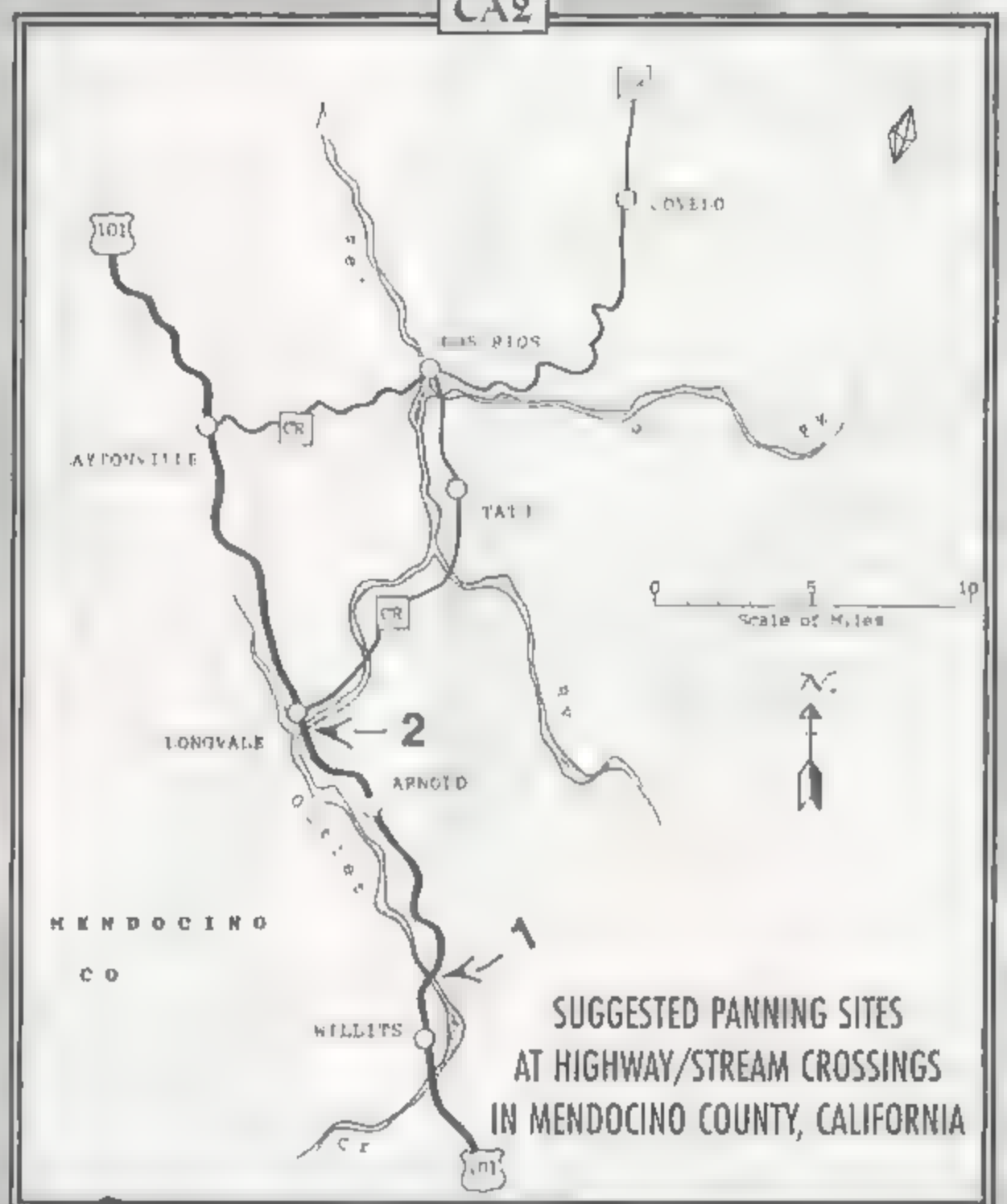

Site 3 Crossing on Russian River, near HEALDSBURG Vicinity finds indicate silicified wood potential.

Mendocino County (Maps CA2-3)
Site 1. Crossing on Outlet Creek, near WILLITS. Vicinity Finds indicate garnet potential

Site 2 Crossing on Outlet Creek near LONGVALE Vicinity finds indicate garnet potential

Site 3 Crossing on Cedar Creek, near LEGGETT Vicinity finds indicate jade potential.

Humboldt County (Map CA4)
Site 1 Crossing on Redwood Creek, near ORICK Vicinity finds include gold and platinum

Del Norte County (Map CA5
Site 1 Crossing on Smith River, near SMITH RIVER Vicinity finds include diamond and jade

OREGON
Curry County (Map OR1)
Site 1. Crossing on Chetco River, near HARBOR Vicinity finds indicate gold potential.

Site 2 Crossing on Pistol River, near PISTOL RIVER Vicinity finds indicate jade potential.

Site 3. Crossing on Rogue River, near GOLD BEACH Vicinity finds indicate gold potential

Site 4 Crossing on Sixes River, near SIXES. Vicinity finds indicate gold potential

Lincoln County (Map OR2)
Site 1 Crossing on Yaquats River, near YAQUATS. Vicinity finds include agate, chalcedony, jasper, and moon stone

Site 2. Crossing on Alsea River, near WALDPORT. Vicinity finds include agate, jasper, and quartz crystals

Site 3 Crossing on Yaquina River near NEWPORT Vicinity finds include agate, chalcedony, gold, jasper, opalized wood, and silicified wood

WASHINGTON
Pacific County (Map WA1)
Site 1 Crossing on Wilapa River, near RAYMOND Vicinity finds indicate silicified wood potential

Jefferson County (Map WA2)
Site 1. Crossing on Queets River, near QUEETS Vicinity finds include agate, jade, jasper, and quartz crystals

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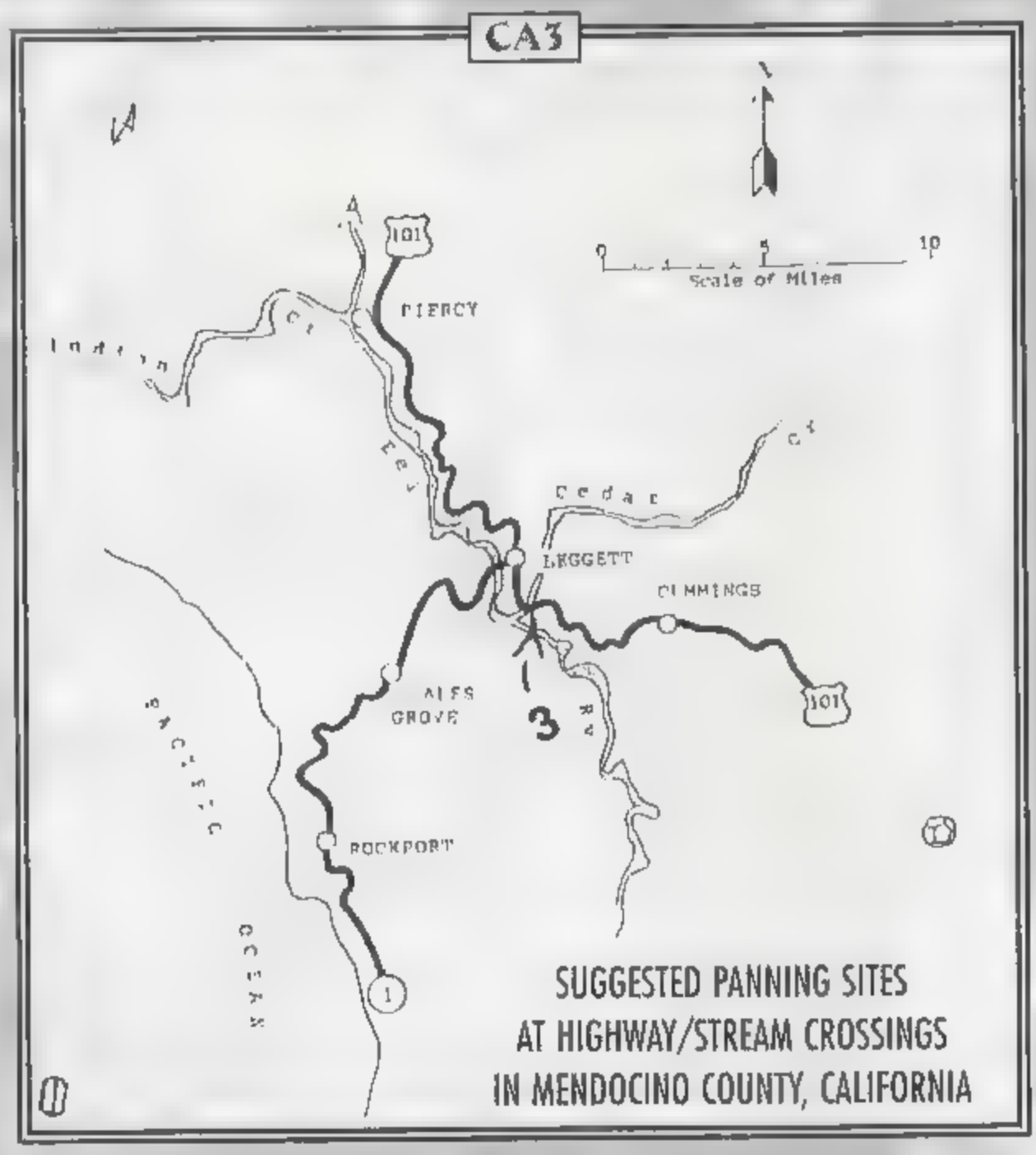
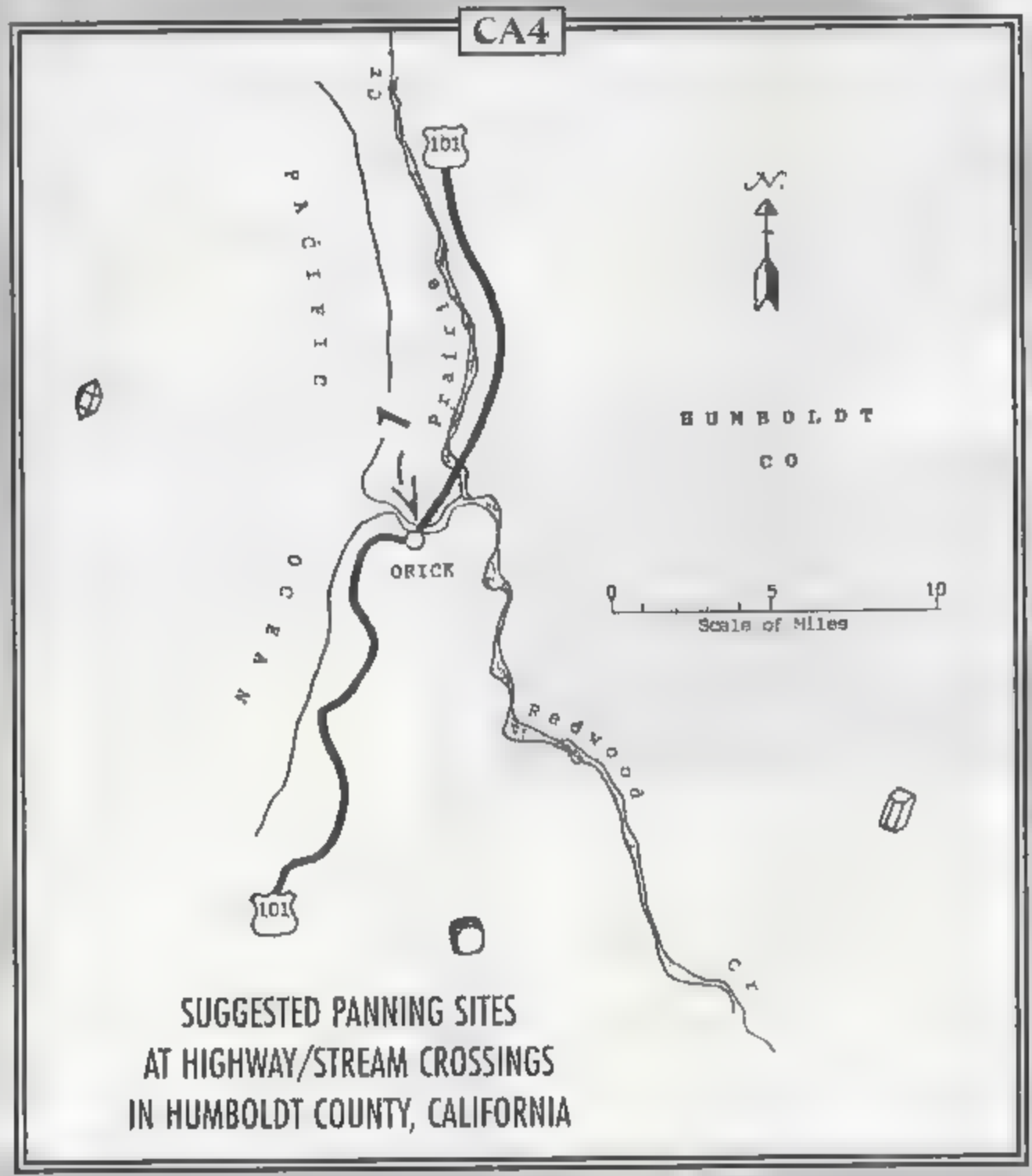
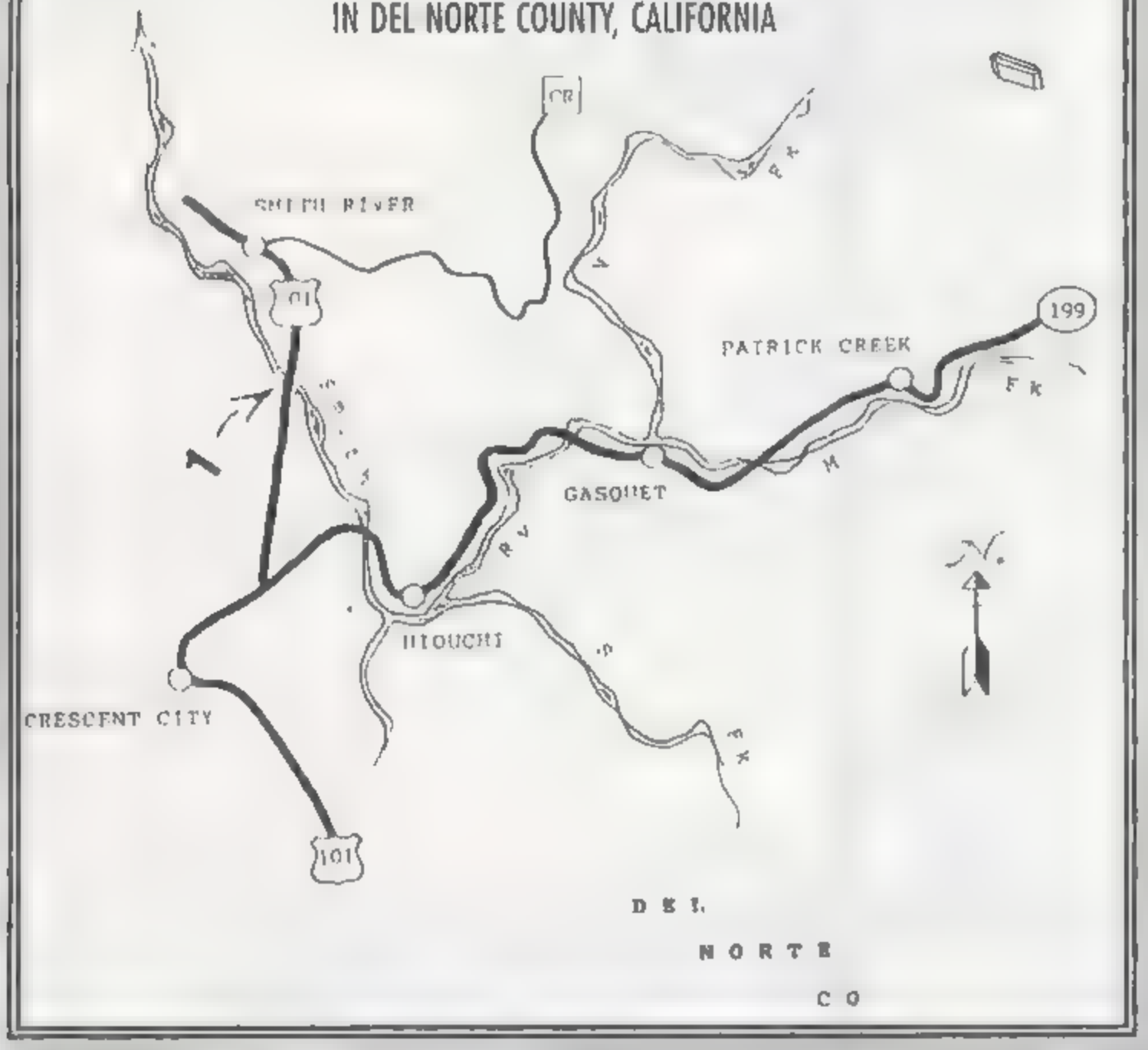




CA5

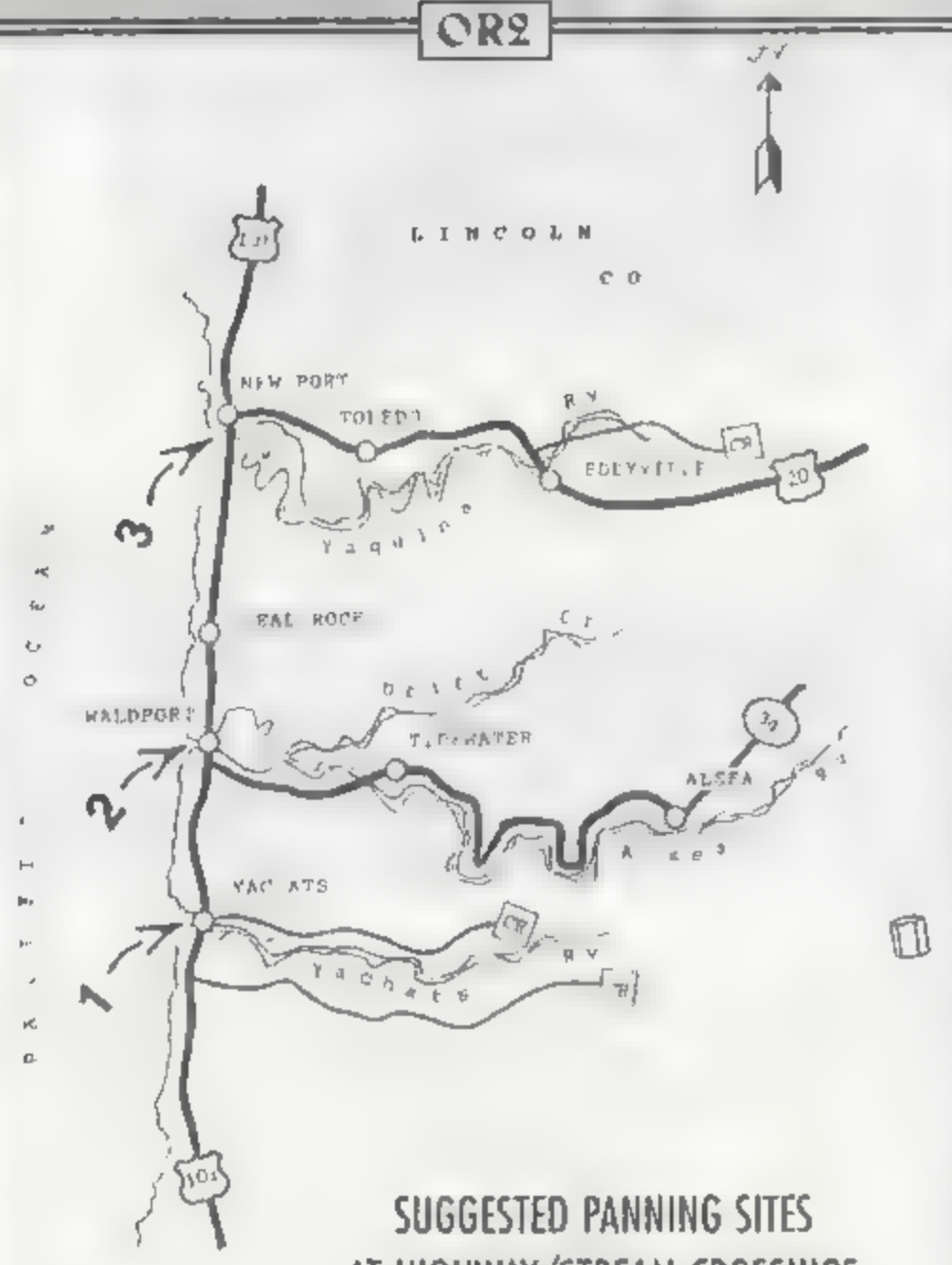
SUGGESTED PANNING SITES AT HIGHWAY/STREAM CROSSINGS IN DEL NORTE COUNTY, CALIFORNIA



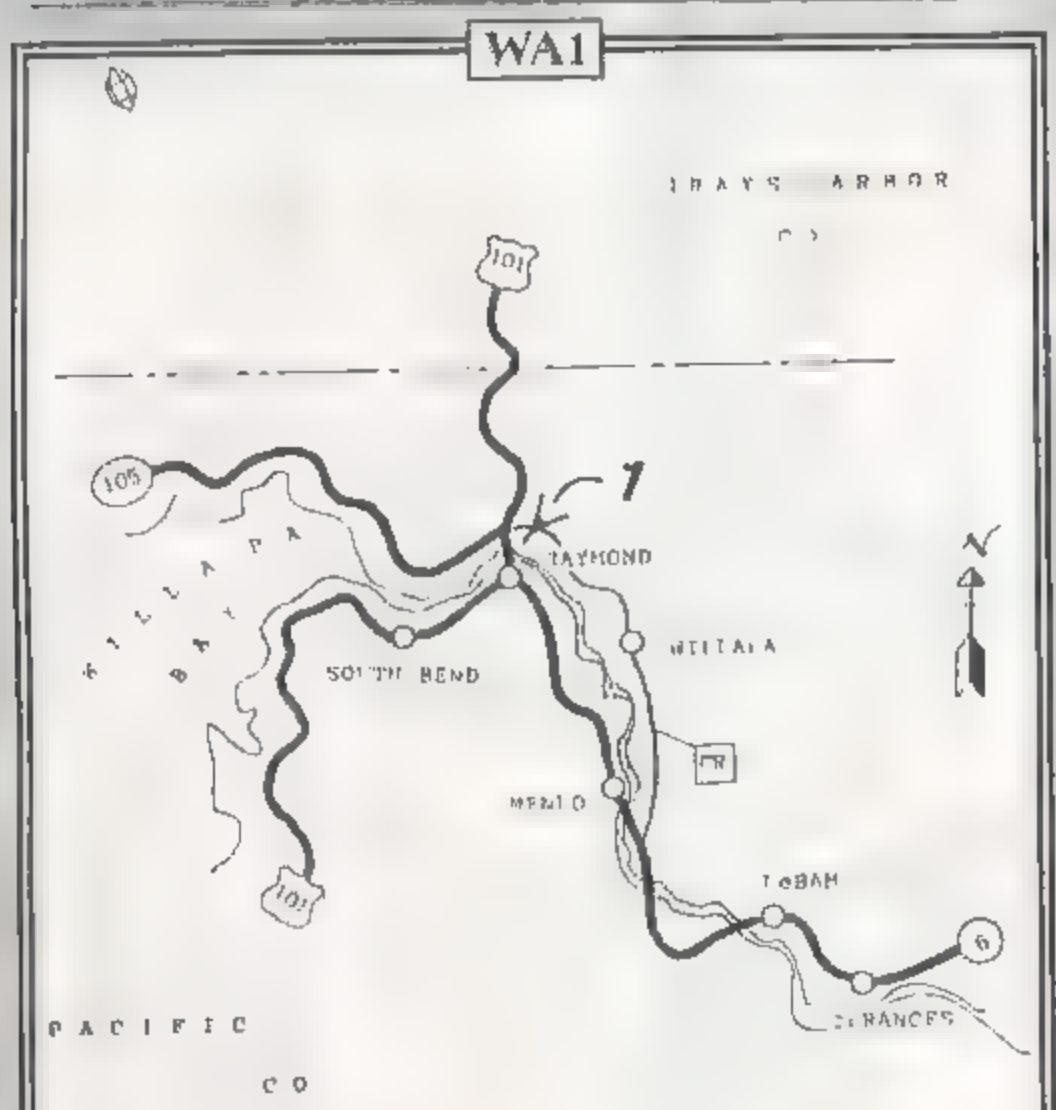
OR1

SUGGESTED PANNING SITES AT HIGHWAY/STREAM CROSSINGS IN CURRY COUNTY, OREGON

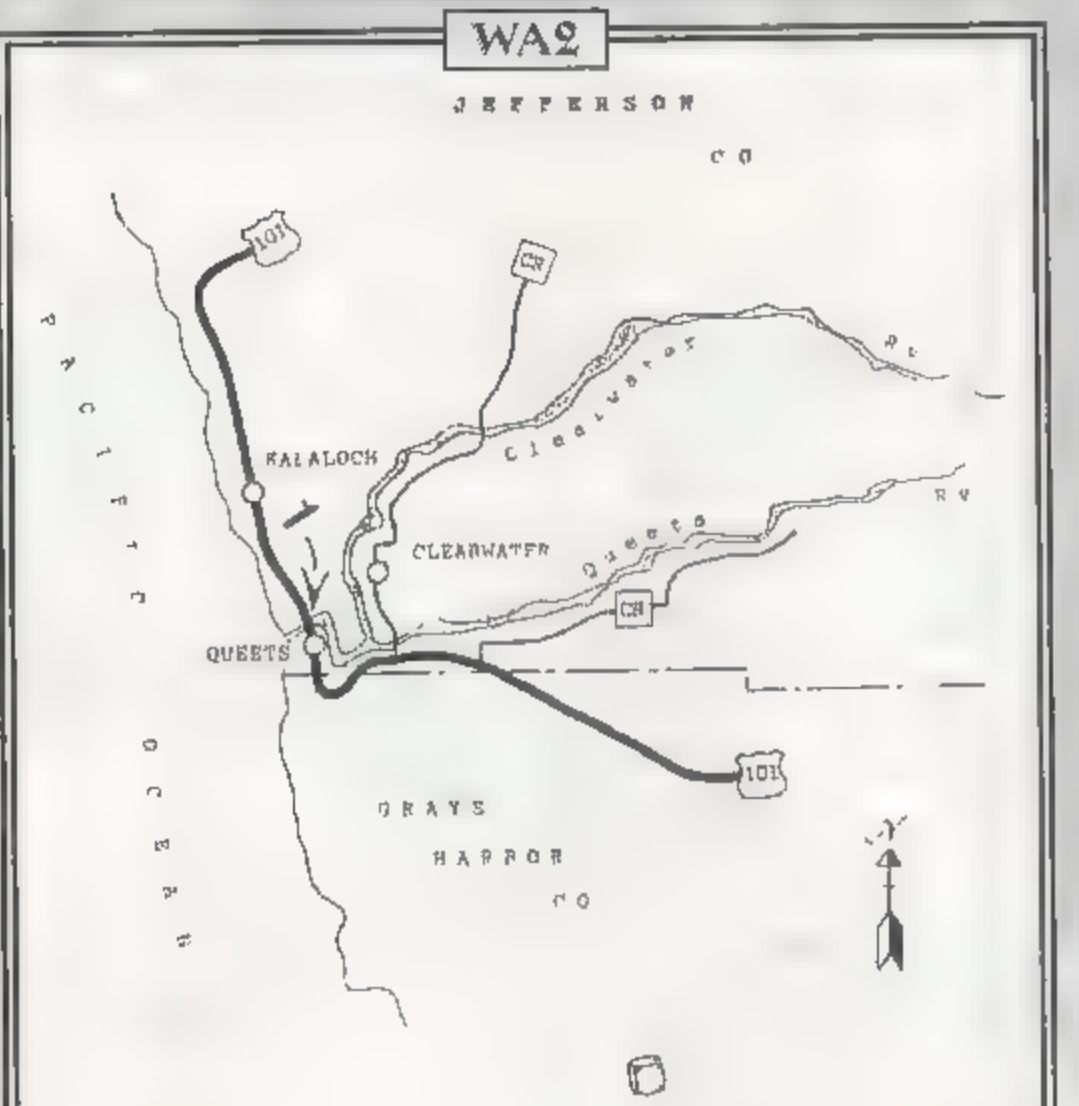
OR2



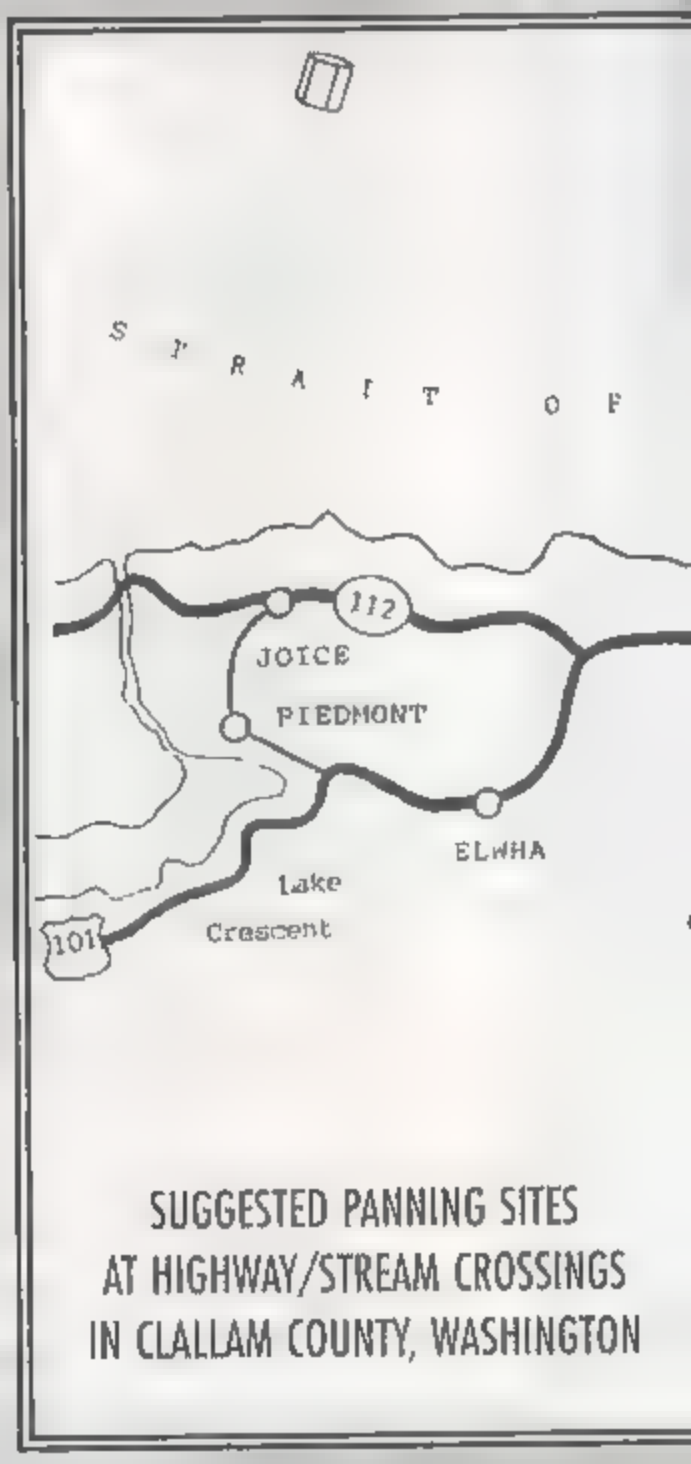
SUGGESTED PANNING SITES AT HIGHWAY/STREAM CROSSINGS IN LINCOLN COUNTY, OREGON



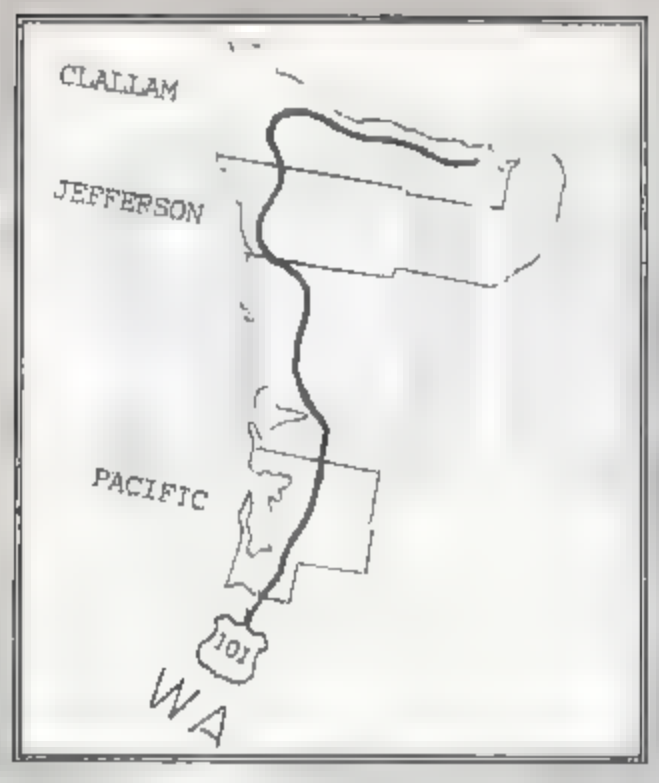
SUGGESTED PANNING SITES
AT HIGHWAY/STREAM CROSSINGS
IN PACIFIC COUNTY, WASHINGTON



SUGGESTED PANNING SITES
AT HIGHWAY/STREAM CROSSINGS
IN JEFFERSON COUNTY, WASHINGTON



SUGGESTED PANNING SITES
AT HIGHWAY/STREAM CROSSINGS
IN CLALLAM COUNTY, WASHINGTON

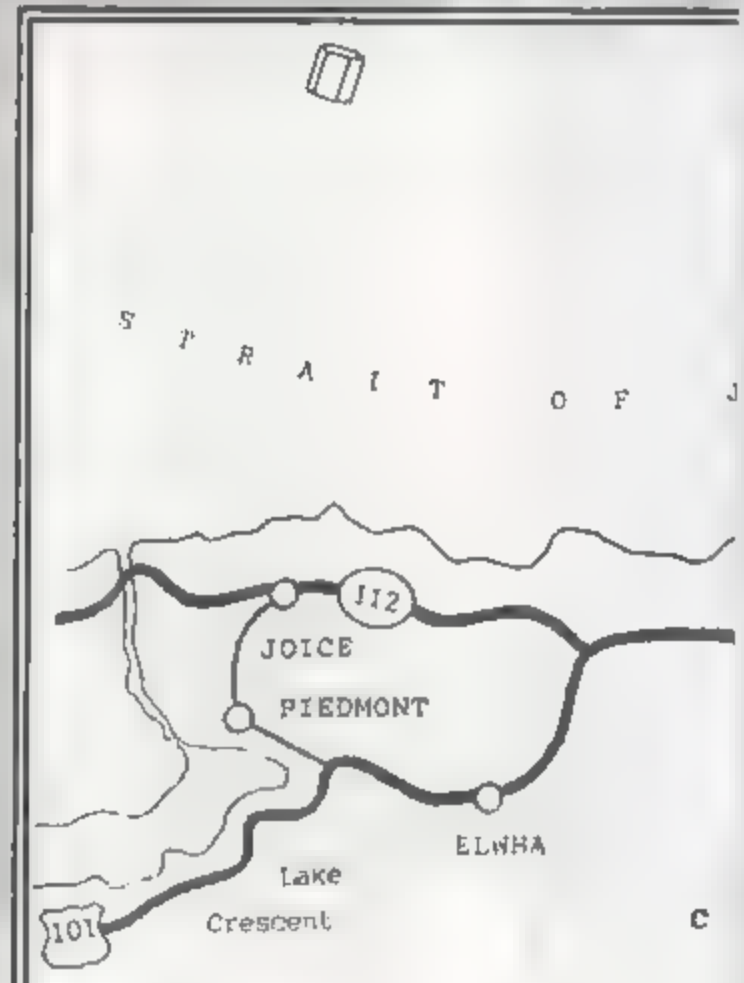


Clallam County (Maps WA3 4)
Site 1 Crossing on Soleduck River, near FORKS Vicinity finds include agate, chalcedony, jasper, and silicified wood.

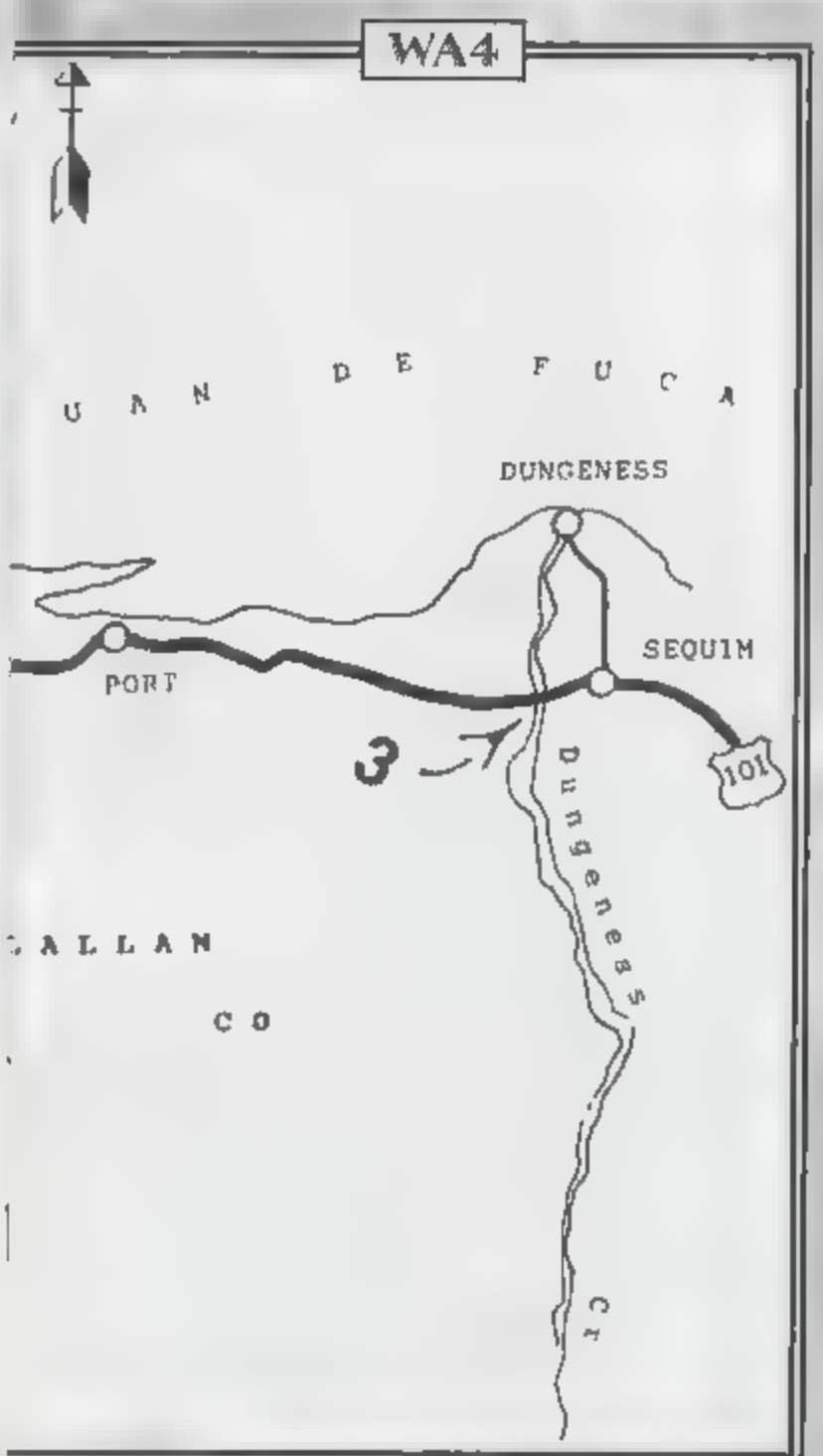
Site 2 Crossing on Soleduck River, near SAPPHO. Vicinity finds include agate, chalcedony, jasper, and silicified wood

Site 3 Crossing on Dungeness River, near SEQUIM. Vicinity finds include agate, jasper, and quartz crystals

We suggest you use the official state highway maps in conjunction with the vicinity maps for overal. orientation in the field



SUGGESTED PANNING SITES
AT HIGHWAY/STREAM CROSSINGS
IN CLALLAM COUNTY, WASHINGTON



Inner Space Cavern

Tour Texas' Newest Show Cave

by William L. Rader

I am enveloped by impenetrable darkness Any attempt I make to discern my right hand, which I am moving slowly back and forth barely an inch from my eyes, is futile The only sound that reaches my ears is the intermittent dripping of water that emanates from points both near and far in the blackness that surrounds me

The darkness suddenly lifts. The primitive fear of the dark that has begun to take hold of me gives way to the sense of wonder I feel at the sight of the fantastic images that surround me The sound of the tour guide's voice provides a bridge back to reality

I am standing a little more than 50 feet below the surface of the earth in the Outer Cathedral, one of the large rooms located in Inner Space Cavern Inner Space Cavern, also known as Laubach Cave, is Texas's newest show cave, having only been discovered in 1963 and opened to the public in 1966. The cavern is located in Georgetown, approximately 25 miles north of downtown Austin The visitor's center is literally a stone's throw from Interstate 35 and is easily accessed by exiting the highway at the mile marker 259 offramp

Inner Space Cavern is a veritable feast for the eyes. As a "living" cave that is actively being formed, Inner Space contains a vast complement of calcium carbonate cave formations, or speleothems These include stalactites, stalagmites, helictites and columns, as well as flowstone, draperies, and coralloids ("cave coral" and "cave popcorn") The cavern is noted for its "soda straw" stalactites, its numerous delicate and erratically growing helictites, its "bacon" drapery, the "sugar candy" texture of its pure calcium carbonate stalagmites, the formation of limonite/goethite boxwork, and a mud crater 1½ feet across called "The Volcano"

But its impressive calcium carbonate formations are not the only reason Inner Space ranks as one of the most interesting and important of Texas caverns Active scientific research has been undertaken in the cavern, some of which is ongoing, with investigation having been conducted in the fields of biology, hydrology, isotopic age dating, speleology, and vertebrate paleontology. In addition, portions of the cavern are still being mapped

Discovery and Development

There were no surface indicators that would have made the drilling crew from the Texas Department of Highways aware that something out of the ordinary would happen to them on that spring morning in 1963 At that time, the crew was drilling 6-inch-diameter test holes to determine whether the ground surface was stable enough to support an overpass on I 35, which was under construction. As the 6-inch drill bit hit a depth of approximately 25 feet, it suddenly free-fell 26 feet. Ten other attempts at different locations met with the same result.

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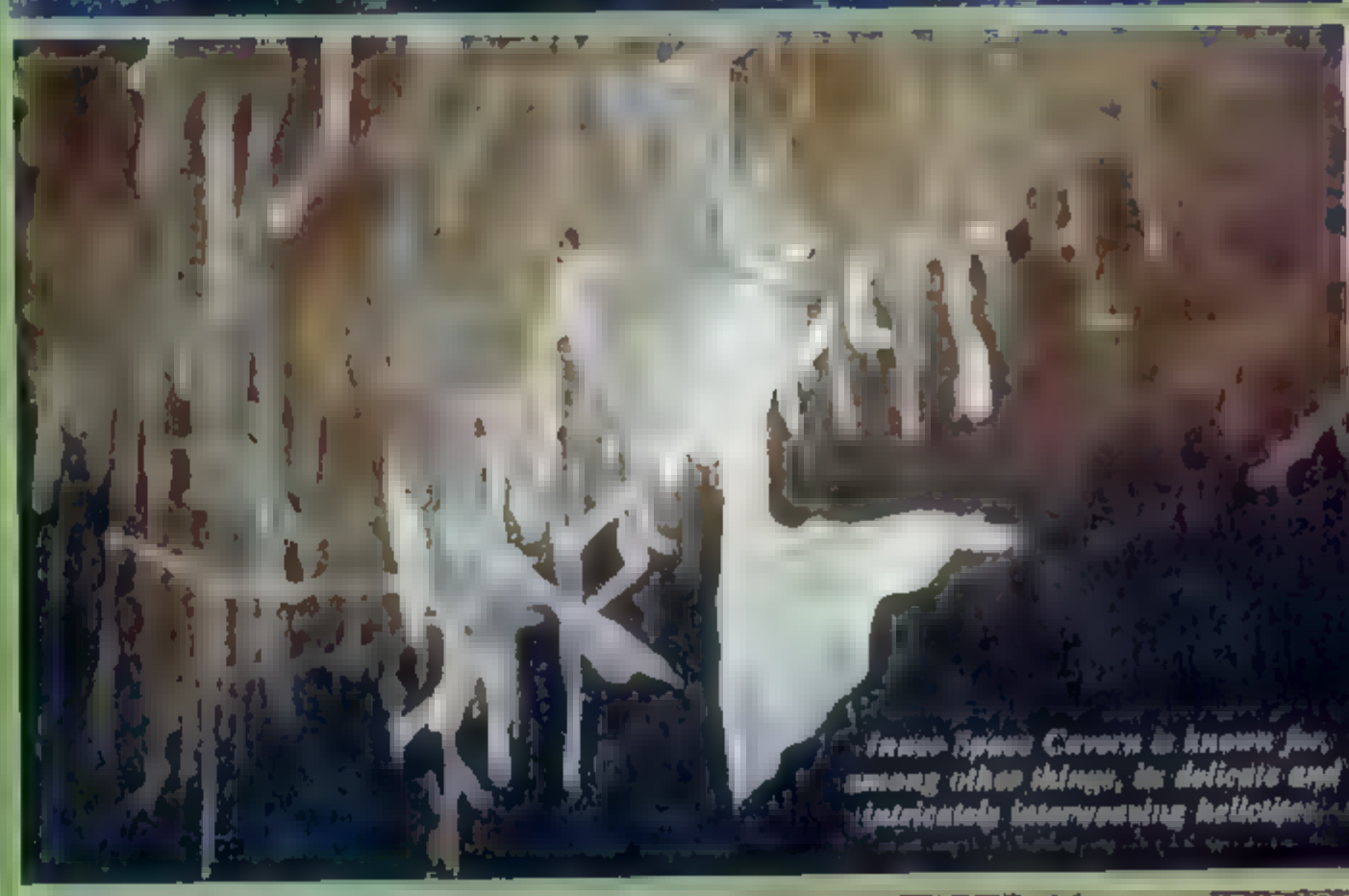
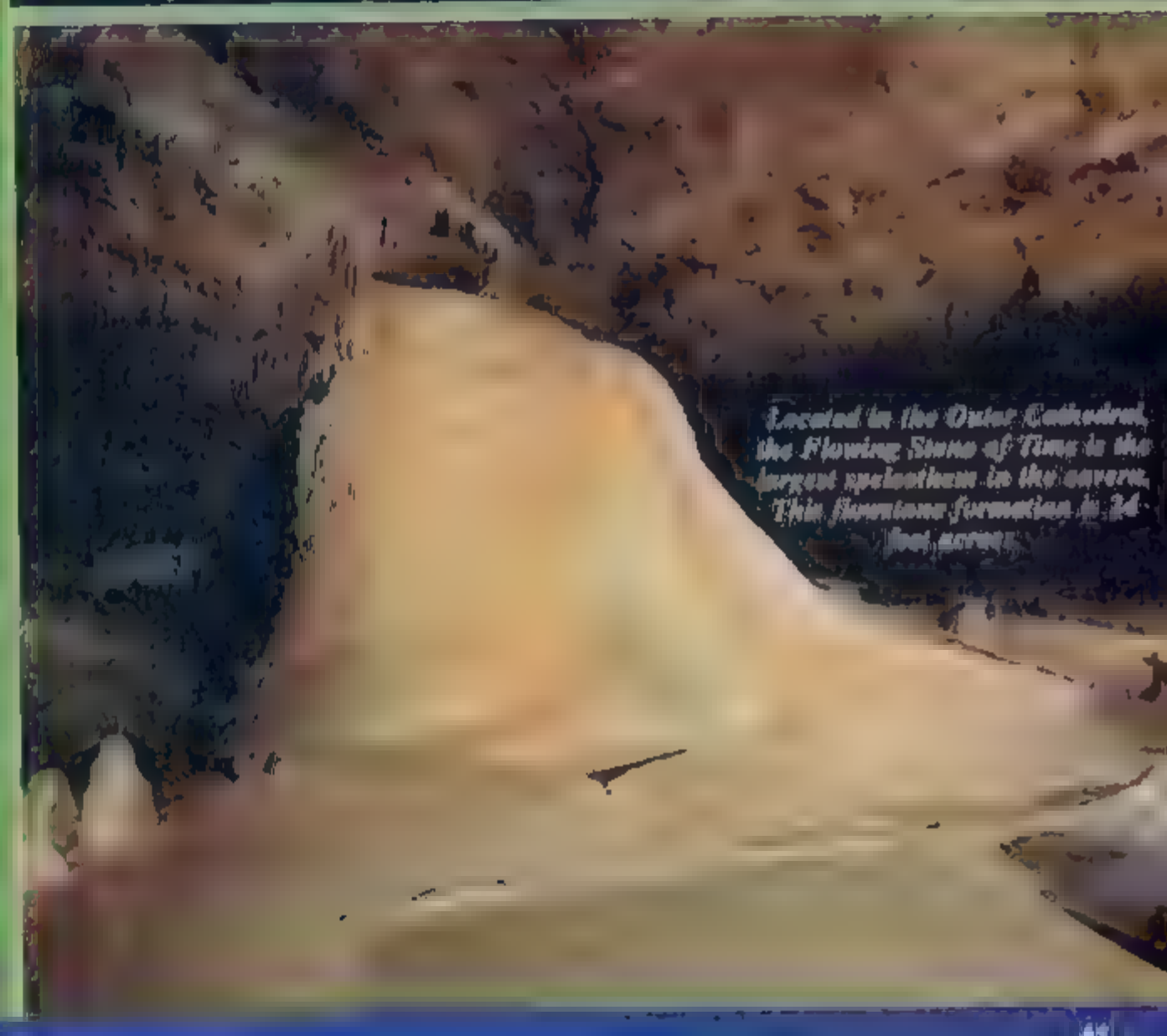




Inner Space Cavern *from page 41*

Realizing that some sort of large cavity lay underground, the decision was made to enlarge one of the test holes from 6 inches to 24 inches in diameter. Riding the drill bit and grasping the pipe stem, a daring volunteer with a light source was lowered into the darkness through 25 feet of rock. Bill Johnson emerged into the large room that was later named the Outer Cathedral. He was the first human to lay eyes on Laubach Cave. Today, the original test holes, including the enlarged hole through which Johnson was lowered into the cave, are visible in the roof of this room. (A portion of the 24-inch core now anchors one leg of the photo display that is located in front of the entrance to the visitor's center.)

After its discovery, the Texas Department of Highways allowed the University of Texas Grotto of the Texas Speleological Society access to the cave. A tripod was placed over the 24-inch-diameter test hole, and one by one 64 cavers entered the cave in November 1963. Each spelunker was lowered into the Outer Cathedral elevator-style by a rope that was tied to a car. A two-way telephone allowed cavers to communicate with one another. Over a period of several days, members of the University of Texas Grotto reconnoitered the cave. They mapped over 7,000 feet of rooms and passages. The cave was then sealed by the Department of Highways, and work on the interstate continued.

In 1964, a group of businessmen formed the Georgetown Corp. The Georgetown Corp. leased the cave from the landowners, the Laubach family, for 99 years and began its development. A sloping shaft was excavated into the cave, which had no natural entrances, and a tour trail with lighting was installed within the cave. The cave was opened to the public in the summer of 1966.

During the commercial development of Laubach Cave, many new rooms and passages were discovered. The impressive discoveries that came with further exploration led the developers to adopt the name Inner Space Cavern. It was envisioned as being the subterranean analog to the exploration of outer space, which at the time was high on the agendas of the world's superpowers. During commercialization, the total length of explored cave increased from the 7,000 feet initially mapped to over four miles.

The Inner Space Cavern Adventure Tour

The hour-and-15 minute Adventure Tour begins at the visitor's center with a 350-foot cable car ride to the mouth of the cave. The first stop is the Introductory Room, where the cavern's formations and rock types are described by the tour guide. From there, the tour along the trail commences.

The Soda Straw Balcony appears almost immediately on the right side of the trail. This room has been appropriately named for the dense, forestlike aggregations of delicate "soda straw" stalactites that have grown downward from the ceiling.

Continuing onward, Sinkhole No. 1 can be seen on the right. At one time this was an entrance to the cavern. However, it was closed up by erosion approximately 14,000 years ago.

Shortly thereafter, visitors pass Drapery Column on the left, and from there the tour moves on to the Breakdown Room. The Breakdown Room derives its name from the large blocks of dolomitic rock that fell from the ceiling and came to rest on the floor. From a geological standpoint, this is one of the most important stops on the tour. Here, a large fracture that is located where the wall and ceiling converge provided an ancient conduit through which water entered the cave. The flow fed an underground stream or river, which provided the erosive power to initially carve the cave out of the Lower Cretaceous Edwards Formation limestone and dolomite.

From the Breakdown Room, the tour continues on to the First Formation Room. In the First Formation Room, there are numerous speleothems, including the eccentrically shaped "broomstick columns" and a rimstone pool.

The trail then enters the spectacular Outer Cathedral (or as it is alternatively called, The Discovery Room). The Outer Cathedral is the second-largest room in Inner Space Cavern. It is the room that the drilling team from the Texas Department of Highways penetrated 11 times on the day of discovery in 1963. The largest flowstone speleothem in the cavern, The Flowing Stone of Time, is located in the Outer Cathedral. This is the oldest speleothem in the cavern, and at 24 feet across, it is the largest. A 1-inch-diameter, 22-inch-long core was taken from the back of this formation. Using the uranium disequilibrium method, the core sample was dated to approximately 35,000 years before present. A large darkened area on the ceiling and petrified guano on the floor indicates a sizable colony of bats once roosted in the Outer Cathedral. It is estimated that this colony inhabited the cavern some 16,000 years ago.

Farther on, the trail reaches another geologically important site in the cavern. The visitor is standing beneath the scalloped ceiling. At this point, the underground river branched, with one branch flowing downhill to the right and the other continuing on in the same direction as the tour trail. The scallops in the ceiling were carved out by the turbulent eddying of the water at the point where the underground river forked, and give evidence of the direction of current flow.

The Press Room is located downhill along the right branch of the ancient river and is not a part of the visitor tour. This room is where the press conference was held when the cavern was opened to the public in 1966. The Press Room is included on the Children's Discovery Tour. During this special tour, young people search for replicas of the fossilized remains of animals that have been excavated in the cavern.

Continuing beyond the scalloped ceiling, the trail passes one side of Bone Sink No. 2. This is one of the most important vertebrate paleontology sites in the state. Bone Sink No. 2 was filled with sediments and closed up approximately 14,000 years ago.

The Castle Balcony appears soon thereafter on the right side of the tour trail. Castle Balcony consists of a series of large cave formations, some of which have been given fanciful names for the make-believe images they appear to represent. The floor below these formations consists of a dark, watery mud in which some animals that

continued on page 44

entered the cave bogged down and could not escape This mud has been given the colorful name "pigpen mud"

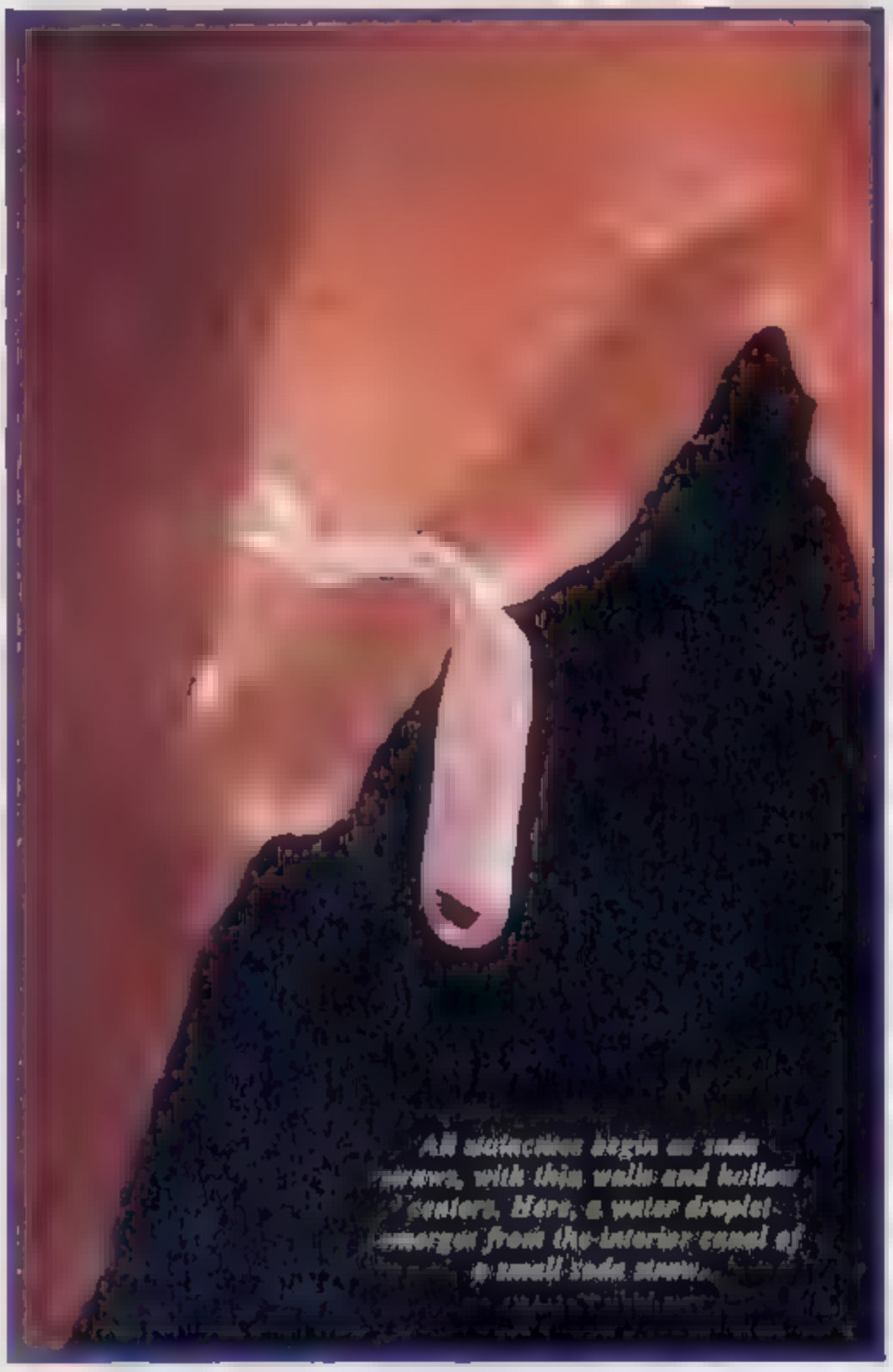
The trail continues through a low ceilinged passageway that has been aptly named Short Person's Revenge On the far side of the passageway, a retaining wall built to contain Bone Sink No 2 appears on the left In 1966 artist Michael Frary painted a mural along this 80 foot expanse of wall Its color images depict some of the large mammals whose fossils were recovered from Bone Sink No 2 including the ground sloth, glyptodont horse, black tailed prairie dog, saber toothed cat, camel, and Columbian mammoth At the far end of the wall a glassed in enclosure houses an exhibit of the fossilized bones of some of these animals

The tour now enters the Inner Cathedral the largest room in the cavern To the left of the trail, in the floor of the room, is a site of former paleontological excavation A small, roped off area once yielded numerous fossils of small vertebrates A shallow pit located immediately behind the small vertebrate site indicates the spot where the complete skeleton of a horse was disinterred Other bones can be seen scattered here and there on the floor

The trail proceeds on to the electrician's ladder This was an alternate entrance used by the crew of electricians who originally installed the lighting within the cavern It is now used as a ventilation shaft, through which air can be pumped into the cavern It is often possible to catch a glimpse of a toad or cave cricket upon the rocks at the base of the ladder

The trail now takes a turn to the left, and visitors walk downhill to Bone Sink No 3 another important paleontological site within Inner Space Cavern This is the oldest ancient opening to the cavern The opening is believed to have closed up very quickly some 23,000 years ago perhaps due to seismic activity Breakdown alters the sloping talus cone of the sink

The trail dead ends at a large room called the Lunar Landscape Prior to man landing on the moon it was imagined that the moon's surface might appear much like this formation filled room This, of course, was not to be the case The debris that was once removed from a pit located in the right forefront of the room held the skeleton of a saber toothed cat



The tour now backtracks along the trail toward the Inner Cathedral Instead of climbing uphill to the electrician's ladder, however the tour moves downhill to the Lake of the Moon This room consists of a particularly aesthetic aggregation of stalactites, stalagmites and columns that are mirrored in the clear waters of a large rimstone pool Nice examples of "cave volcanoes," or geysermites, are found in the pool

The Lake of the Moon is the last stop on the trail and, at 69 feet below ground level is the deepest point on the tour At this time, visitors backtrack along the 1,844-foot trail and once again see all the sights in reverse order'

Biology of Inner Space Cavern

About 1,200 species of terrestrial and aquatic animals have been recorded from Texas caves Some of these species are troglobites, animals that spend their entire lives in the dark zones of caves and which often lack eyes and pigment Others are troglophiles, animals that live in the dark zones of caves but which can also be found living outside the cave environment

Inner Space Cavern is home to a diverse fauna of troglobites and troglophiles All are terrestrial invertebrates, and all are insects or other arthropods *Cambala speobia* is a species of troglobitic millipede that coils up in response to light even though it is eyeless A pair of blind beetles live in the cavern, *Rhadine sp* and *Texamaurops sp* The latter may be a new species, and very few examples have been collected in the cavern There is one species of eyeless spider, *Cicurina sp* The U S Fish and Wildlife Service has listed as endangered two troglobitic species that make their home in the cavern These are *Texella reyesi*, the Bone Cave harvestman (a kind of daddy longlegs spider), and *Batrisodes texanus*, the Coffin Cave mold beetle

Common troglophiles that inhabit Inner Space Cavern include millipedes, beetles and the springtail, a diminutive hopping insect One common troglophile worthy of special mention is *Vejovis reddelli* This is a sizable, dark-colored scorpion that, while not dangerous, may deliver a painful sting

Some animals may enter the cavern accidentally Field mice have been spotted at the entrance, pillbugs have been found near the 24 inch diameter core hole in the Outer Cathedral, and toads and at least one nonvenomotos snake have been discovered at the base of the electrician's ladder in the Inner Cathedral Cave crickets (*Ceuthophilus sp*) are also commonly seen in the vicinity of the electrician's ladder Cave crickets exit the cavern at night and return to roost in the cavern during the daytime hours The crickets are therefore classified as trogloxenes, animals that roost in caves, While Inner Space Cavern is no longer a home to a colony of roosting bats, a small number of solitary eastern pipistrel (*Pipistrellus subflavus*) may be found living within the cavern and hibernating near the entrance during the winter months

Paleontology of Inner Space Cavern

The fossilized remains of a large number of vertebrates have been recorded from Texas caves Inner Space Cavern is no exception The cavern is considered to be one of the most important paleontological sites in the state Up to the present, 144 species of vertebrates have been excavated from the sediments of Inner Space Cavern The fossils recovered from the cavern represent animals that are both

living and extinct.

Remains in the cavern have been excavated from five talus cones, or bone sinks, as they are more commonly called. Each talus cone represents an ancient cave entrance, or sinkhole that was filled in by sediment and closed up. As we learned, the exception is Bone Sink No. 3, which is believed to have closed very quickly, perhaps due to seismic activity. All of the talus cones are Late Pleistocene in age, and evidence indicates that each of the cave entrances may have been open at a different time. Radiocarbon dates have been derived from an analysis of bone for three of the talus cones. Bone Sink No. 1 has a date of 15,850 plus 310 years before present. Bone Sink No. 2, 13,970 plus 310 years before present, and Bone Sink No. 3, 23,230 plus 490 years before present. The latter is the oldest radiocarbon date that has come from a Texas cave.

The bones of amphibians, reptiles and mammals have been recovered from Inner Space Cavern. The cavern contains an especially wide range of mammalian species. Large mammals whose remains have been excavated from Inner Space Cavern include the Columbian mammoth (extinct), Jefferson's ground sloth (extinct), a glyptodont (a very large extinct armadillo), the spectacled bear (extinct), the black bear, the jaguar (an extinct subspecies), the bobcat, the dire wolf (extinct), the coyote, the white-tailed deer, and the raccoon. Bones of extinct species of bison, saber toothed cat, camel, and horse have also been excavated, as have small mammals such as rabbits, rodents and bats.

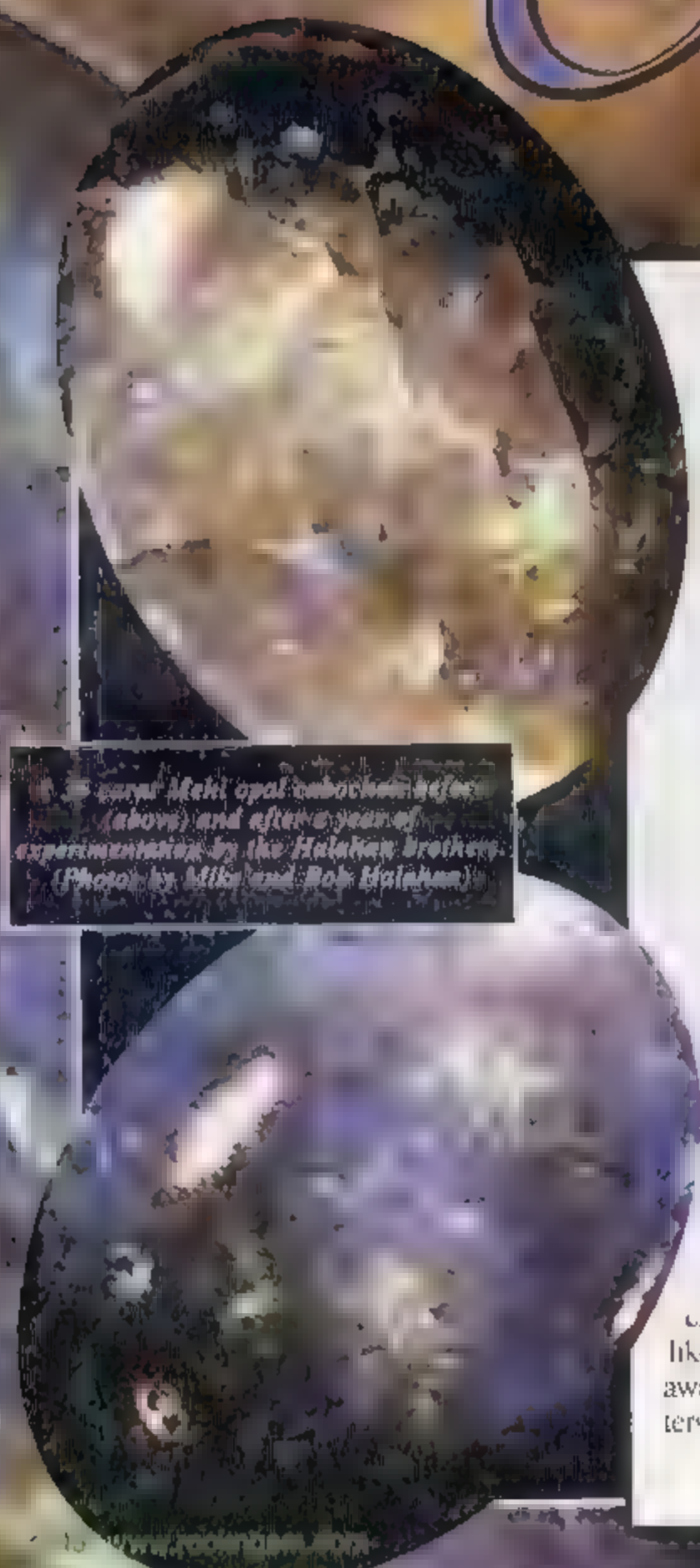
The fossil for which the cavern is best known is an extinct species of peccary, the flat-headed peccary. The peccary is a large, piglike mammal with sharp tusks that inhabits the Americas. Large numbers of bones from animals of all ages have been recovered. It is not known whether the flat headed peccary served as prey for the jaguar or inhabited an ancient entrance to the cavern.

To reach the caverns, take I-35 Exit 259 in Georgetown, Williamson County, Texas. The cavern trail is wheelchair accessible. Adventure Tour tickets are $12 for adults, $7 for children 4 to 12, and children 3 and under enter free. An Adventure Tour departs every 15 to 20 minutes. Tickets are sold on a first come, first served basis.

Inner Space Cavern is open 7 days a week from 9 a.m. to 4 p.m. weekdays and 10 a.m. to 5 p.m. weekends. For off season and holiday hours or group rates, call (512) 931-CAVE or visit www.innerspace.com for a $1 off coupon.

Healing Crazed Opal

Have These Brothers Achieved the Impossible?



Crazed Meki opal cabochon before (above) and after 6 years of experimentation by the Halaiken brothers. (Photos by Mike and Bob Halaiken)

The crazed Virgin Valley, Nevada, opal cabochon before treatment (above) seem to have been healed after 6 years of treatment.

by Barbara McCondra

There is a word that is only whispered to the opal vendor's world: cracky. Unstable, crazed opal is an oft avoided topic although we all know it exists. We all have a drawer with a few cracky chunks of rough or crazed cabochons. By cracky, I do not mean fractures caused by impact. I refer to the cracking that looks webby, like a hook, or like parched earth. We hide these pieces away to not be reminded of most opal cutters' fear.

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Healing Crazed Opal *from page 48*

I was cleaning out some of my workshop drawers and came across a little petri dish holding four magnificent, brightly twinkling gem opals. They were my top specimens of crazed opal, one cabochon each from four opal fields of Lightning Ridge, New South Wales, Australia: Mehi, Emu, Gravel Pit, and Smith's Rush. All are sedimentary opal deposits and all produced some stable opal. Unfortunately, a large percentage proved to be unstable, even though all the sites are within a 30-mile radius of Lightning Ridge, which is known for its expensive, durable and stable opals.

Emu and the Gravel Pit both produced stable gem opal, *but* if the opal was cut with even a hint of matrix (a sludgy looking potch) attached, it was sure to crack. The Mehi opal often had a suspicious yellowish tinge that can be an indicator of unstable opal. Because the pattern and fire were so remarkably intense, vibrant and desirable, buyers bought it anyway, much to their later disappointment. Not all of the Smith's Rush opal was cracky, either. However, much was a very gray material, and most buyers on the field paid half or less per carat than they would have if the opal were on rich, glassy black. Some gray opal has a tendency towards being unstable so buyers pay less for the gamble.

Every opal field has its poor stability areas, often blamed on the extreme depths from which it was mined. That theory was partially disproved when Emanuel Christianos dug below a deep, cracky level in South Australia and found great, hard, stable opal.

I have often found that when the rough opal tasted salty, it was prone to crazing. Any murky looking opal is suspect. Opal with ginger whisker or gypsum stain doesn't hold up well. Piebald potch backings (mixed gray and black potch) is sometimes cracky, sometimes not. The percentages of stable versus unstable change depending upon whether the opal was of sedimentary (as in Australia's Great Artesian Basin) or volcanic formation (as in Mexico, the United States, Canada, or eastern Australia's coastal area). Popular opinion holds that sedimentary formed opal is, percentage-wise, the most stable. That's why Australia provides approximately 95 percent of the world's market opal for jewelry.

Today we have a world market that is more and more accepting of the treating of gems, such as oiling and heating sapphires and emeralds; irradiation, heating tanzanite to turn it purple, filling diamonds, growing rubies, emeralds and opals in the laboratory, and other enhancements and constructions like triplets and doublets. So of course, experiments with stabilizing opal are popular, although somewhat secretive. Experimental studies of stabilization, enhancement, and even repair of already crazed opals are being conducted in both gem industry laboratories and inventors' backyard sheds.

Soaking cracked opals in epoxy, resin, or glass fillers are the most common methods for stabilization or repair. Many years ago, a Chinese jeweler whispered to me that I should soak uncracked opal in hydrochloric acid for three weeks to greatly improve its fire! I never tried it, however, I am previewing the experimental notes and findings that a couple of brothers, Mike and Bob Halahan, who mine Virgin Valley, Nevada, and California opal, have shared with me. The notes cover their many years of experimenting with the stabilization of opal, the improvement of opal color and fire, and the "healing" of crazed opals. They are not healing opal that has been broken due to impact. They are healing the kind of crazing that many opal lovers over the years have attributed to a drying out of the moisture in the opal.

> Each of four crazed Mehi opals came back to me healed of most of the cracks, save one or two, and one stone came back with much more red in the stone where it had once had only pink fire.

The Halahans are even challenging the assertion that the percentage of water in opals has to do with crazing. They submitted specimens of Spencer, Idaho, opal (best used as a triplet because of its cracking tendencies) for analysis and were told its moisture content was approximately 4.5 percent. They also had good, stable Australian opal analyzed. It was found to have a water content of between 6 and 7 percent. Their theory is that air and its compression between the silica spheres has more to do with stability than moisture content does.

EXPERIMENTAL EFFORTS OF THE HALAHANS

That's right, they are not working with the moisture factor. Mike and Bob are healing opals by reversing the chemistry of crazing through a reversal of ionic exchange. The healed opal looks as though opal has grown to fill in the cracks. They achieve better "healing" results with Australian opal than with Virgin Valley opal. Most of the earlier experiments were with Virgin Valley volcanic opal, which has often amazed the Halahan brothers by a surprising natural increase in red fire in the same stone as the years pass, and by developing red fire even though when it was originally mined the opal showed no trace of red fire! They have sampled dirt from the Virgin Valley opal bearing claims and compared it to dirt from nonproducing mines. They found that the pH factor of the dirt seemed connected to whether opal "happened" or not.

Bob discussed this with me excitedly. "We learned that in V[irgin]V[alley], the 'precious' opal could only grow in a pH of 8½. On claims that didn't have opal, the pH was below 6 and sometimes down to 4. We took readings from a lot of claims that never did and never will have opal on them because they never had a high enough pH. I know this may not have anything to do with Aussie opal, but it is info that we gathered in a place called Virgin Valley, Nevada."

Over the last 18 years, Mike and Bob have kept me posted on their progress. Their efforts these past six years have been focused on Australian opal. Four years ago, I gave them samples of both uncracked rough and severely crazed cabochon-cut opals from the Lightning Ridge area of Mehi. Over the past three years, they have had great success in healing most of the crazing, but not all of it. A surprise benefit of their process is the changing of pink fire into red fire! Each of four crazed Mehi opals came back to me healed of most of the cracks, save one or two, and one stone came back with much more red in the stone where it had once had only pink fire.

One particularly wonderful specimen of severely crazed Mehi opal is a magnificent, thick, high-domed cabochon weighing 35 carats. It was so badly crazed that it looked ready to chip off in flakes with a flick of your fingernail. The brothers have been working on it now for three years and I get to visit it for a craze check several times a year. This year, at the July Fiesta of Gems in Culver City, California, the boys showed me the opal and asked if I noticed anything new. My instant response was that it looked as though the center area had been somehow opened up and flakes or plates of light electric blue-green fire crammed in to "fill" it more profusely than it had been before. It seemed the pattern was fuller and "more."

"Aha!" they said. "Yes, the patterns are changing, and notice that along the edge the patches of color pattern were smaller and progressed to larger and broader patches toward the middle of the stone."

The opal is still changing and there is not a crazing line to be seen, save one potch shadow line! I also noticed a touch of red fire deep within the stone that hadn't been there previously. Another major development was that the gray potch on the back was becoming a "waterbar," meaning that it was beginning to look like jelly opal with holographic, ghostly fire floating within. Did this mean the potch was turning into precious opal? Yes, say the enthusiastic brothers.

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Healing Crazed Opal *from page 51*

Are they the first to achieve these results? Or is the process perhaps being worked on by the Chinese, who bought several years ago, as opal field rumor has it, many millions of dollars worth of Mehi opal in the rough for a greatly discounted few million? The miners speculate that they bought Mehi for inlay purposes, cutting the smaller pieces of opal inside the craze lines.

There is an opposing theory. A few stabilization inventors are of the opinion that crazing continues no matter how small the piece of opal is, as they feel crazing is not from stress on the opal that gets relieved once the crazing occurs, nor from the water within evaporating. This is food for thought!

Try this for dessert. At present, the Halahan brothers, the perpetually persevering amateur scientists, are working on turning potch into fire, and are having some success with both gray and white potch! They certainly have my attention, even though they say that over the years no one seemed to pay them much heed except the Gemological Institute of America (GIA), Len Cram of Lightning Ridge, Australia, and me. The GIA's research department is watching the Halahans' investigations! The brothers have been bringing their experiments to the GIA for many years now, and the prestigious gem institute has photographed their progress in healing cracks. The GIA ran a few tests to verify that no foreign substance had been added to fill the cracks. The healed opal passed those tests.

The major research has been done by Mike, and he is at present working on his first manuscript to the GIA, following strict GIA guidelines. Dr. Jim Shigley, who is director of research at the GIA, has been getting together in private meetings with Mike and Bob for about five years, following their progress. In that time they have shown him how they have been able to move the structure in opal and create new fire. The brothers admit that the rearranging of the silica spheres that are the structure of opal is a slow process. One to two years can make a big difference in the beauty of an opal.

"Opal is opal. Some of it just has a problem in development, and we think it tries to rearrange its structure to get at the place it wants to go," says Bob, spokesman for the two brothers. They have found that some opals are slower to change than others, and some never change. They seem to have no luck with changing volcanic-formed Mexican opal.

I do not know what the Chinese are developing or what success other backyard scientists are having. Even my good friend, author, historian, and discoverer of opal secrets Len Cram doesn't completely fill me in on the progress of his stabilization and healing experiments. I can tell you some of what Bob and Mike have been doing.

Opals have taken quite a beating in the Halahans' persistent attempts to unlock Mother Nature's opal secrets. They began by trying to stabilize the Virgin Valley, Nevada, opal they were mining. Their early, as they call them, Dr. Jekyll and Mr. Hyde experiments involved putting opals in test tubes of hydrogen peroxide for months at a time. This produced a bubbling that continued for months without success. Next, they used dry ice in a liquid form to soak the opals, without luck. Their next unproductive experiment involved soaking opals in Aqua Regia acid. Then they decided to really put the pressure on—literally! They capped a 1-foot 1½-inch diameter pipe at both ends. In the center, they welded a smaller pipe with a valve on it. They filled their contraption with 500 pounds of pure nitrogen and the opals. All they admitted to me was that it had "some" effect on the opal.

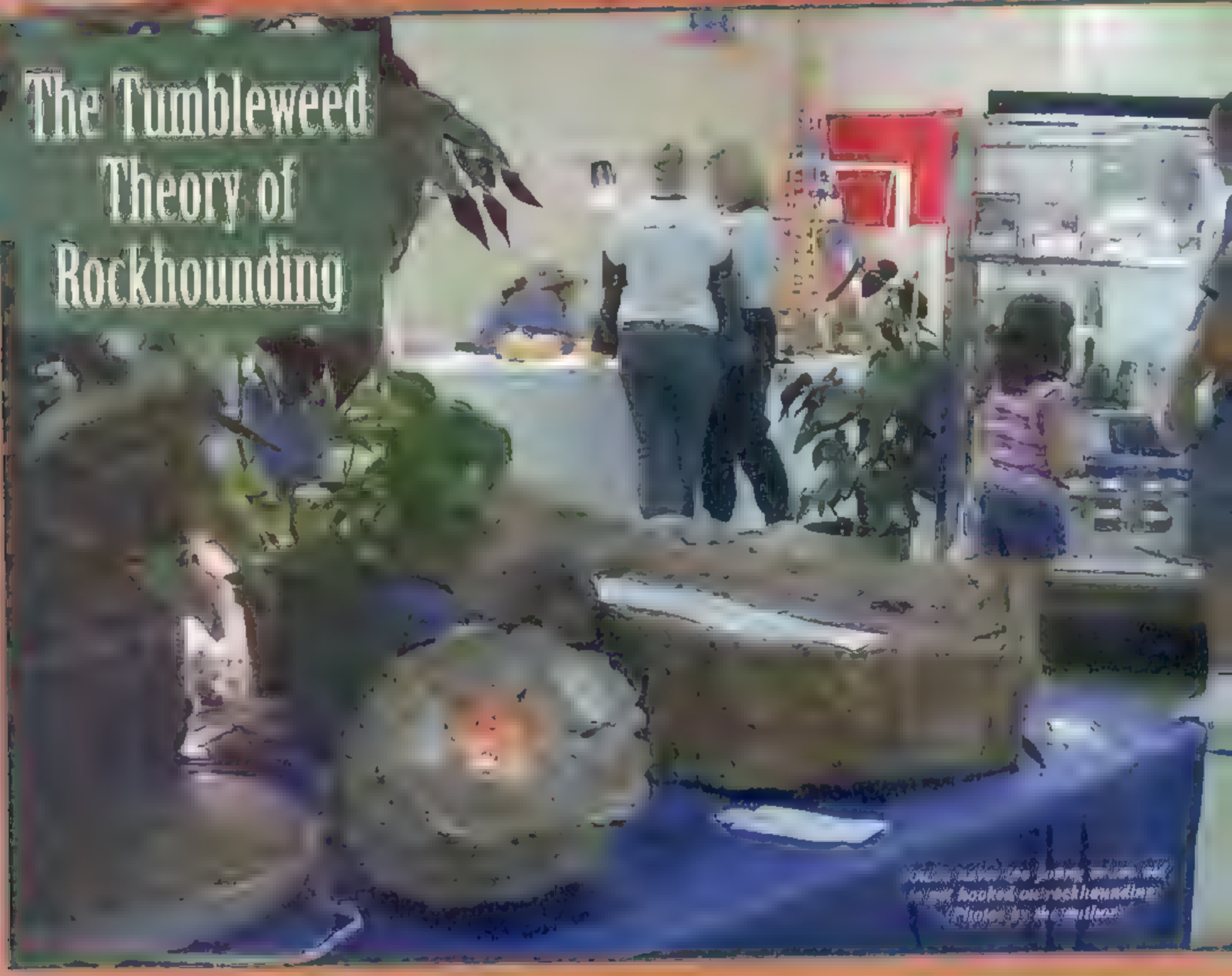
The most fruitful of their opal experiments was what they refer to as the "hot pot" test. Bob described it to me in this way: "Since the Virgin Valley opals had to be protected when you try to set the structure, we put them in a solution of triethelene glycol in a heating pot. We heated the solution to 125 degrees F." They had pretty good success with stabilizing quite a few opals, but it wasn't the final answer to the problem. The brothers say they feel there is no way to stabilize every opal, either Virgin Valley or Australian. Their most recent and most successful procedure is still their little secret for now.

Len has a secret process of turning opal bearing clays into opal, which has created quite a stir in scientific circles and in the opal fields where he lives (see "Lab-Grown Opal," page 52, October 2001 *Rock & Gem*). I introduced him to Mike and Bob about five years ago, and they spent some time with their heads together, discussing their processes while trekking some of the opal fields of the United States. Later, when I tried to discuss with Len the Halahans' efforts, Len did not say a word, but assumed an enigmatic smile instead. What opal-healing experiments are brewing in your backyard shed, Len?

The Halahans are ready to share some of their secret experiments at the 35th annual American Opal Society Opal and Gem Show in Anaheim, California, Nov. 2-3. Bob will be in attendance, and the opals showing the results of their experiments will be on display at the show. It will be held at the Quality Hotel, 616 Convention Way, across from Disneyland. For more information, call Bob Dixon at (714) 525-7635, or e-mail him at jaycarey@gte.net.

Scattering S

The Tumbleweed Theory of Rockhounding



by Lynn Varon

The 2011 Ventura County Fair which took place from July 21 through August 1 included a number of gem and mineral displays by members of the Ventura Gem & Mineral Society, the Oxnard Gem & Mineral Society, the Woodland Hills Rock Chippers, the Conejo Gem & Mineral Club, and a number of individuals from Los Angeles, Ventura, and Santa Barbara counties with no club affiliation.

Judges' ribbons marked the nest of the best, gratification for the hard working hobbyists who had put them together. But fair volunteer David Champion saw an even greater good stemming from the presence of these exhibits at the fair. He explained to me that it was part of his "tumbleweed theory of rockhounding." In short, as a tumbleweed rolls across the landscape, it drops seeds, thus producing vast numbers of new tumbleweeds. The rock and mineral tent at the fair is one of the "seeds" dropped by local hobbyists in the hopes of producing new rockhounds.

"If each person uses their enthusiasm to spread their hobby to other people and they in turn do the same thing, our hobby will continue to grow and spread indefinitely," David said. He has been a rockhound for nearly three-quarters of a century, and certainly has enthusiasm to spare. From inside a bank of display cases, he dispensed information and goodwill and was more than happy to engage passersby in conversation about his hobby. "I gave a talk called So You Want to Be a Rockhound," he said. "I have a piece of flexible sandstone from North Carolina. It catches everybody's attention! There are so many of these unique things, but the general public is not aware of their uniqueness."

David, who picked up his first specimen at the age of 5, understands that the enthusiasm of youth has been responsible for many a convert to the hobby. "Most children," he says, "sooner or later, go through a phase where they're interested in fossils,

Top: A Ventura Gem & Mineral Society display educates visitors about crystals from Lawrence County, Indiana. Center: Pages from Rock & Gem *magazine enhance this display of feldspars by the Oxnard Gem & Mineral Society. Bottom, Lapidary Bill Ulmen put together a blue-ribbon case of mineral spheres.*

The result is that, this is the time to catch their attention." He knows of two young people whose early interests in minerals and fossils led them to careers in geology and paleontology.

A member of the Conejo and Oxnard societies and a life member of the Santa Monica Gemological Society, the Culver City Rock & Mineral Club, and Westside Mineralogists, David believes he couldn't live in a more advantageous place for converting new rockhounds. "We have here in Southern California a remarkable geological setup. If we draw a circle of approximately 300 miles centered on Ventura County, within that circle there's a greater abundance and a greater variety of gem, mineral, geological, paleontological and lapidary materials than one will find probably in any similar sized spot in the entire world."

To illustrate his point, he offered several examples. "Within this area we have the second-most heavily mineralized district in the entire United States, which is Crestmore Quarry in Riverside, California. There are about 200 different minerals found at Crestmore Quarry. We also have the world's largest deposit of Pleistocene fossils, which is the La Brea Tar Pits. A similar but less exploited, or shall we say less known area for the Pleistocene fossils is in the oil fields around McKittrick and Taft — where there are also very large beds of tar that also trapped Pleistocene fossils 16 million years ago. Incidentally, in that particular area there's a very great abundance of — the agate nodules which are there for the picking up.

"Gem Hill is the north side of the Rosamond Hills and this is a unique area in that it is so paved with anywhere from fragments to large pieces of agates and jaspers and petrified wood and palm root and other rather desirable materials that literally 20 percent of what you would pick up blindfolded could go into a tumbler and be polished in to gems. And it's rather easy to get to."

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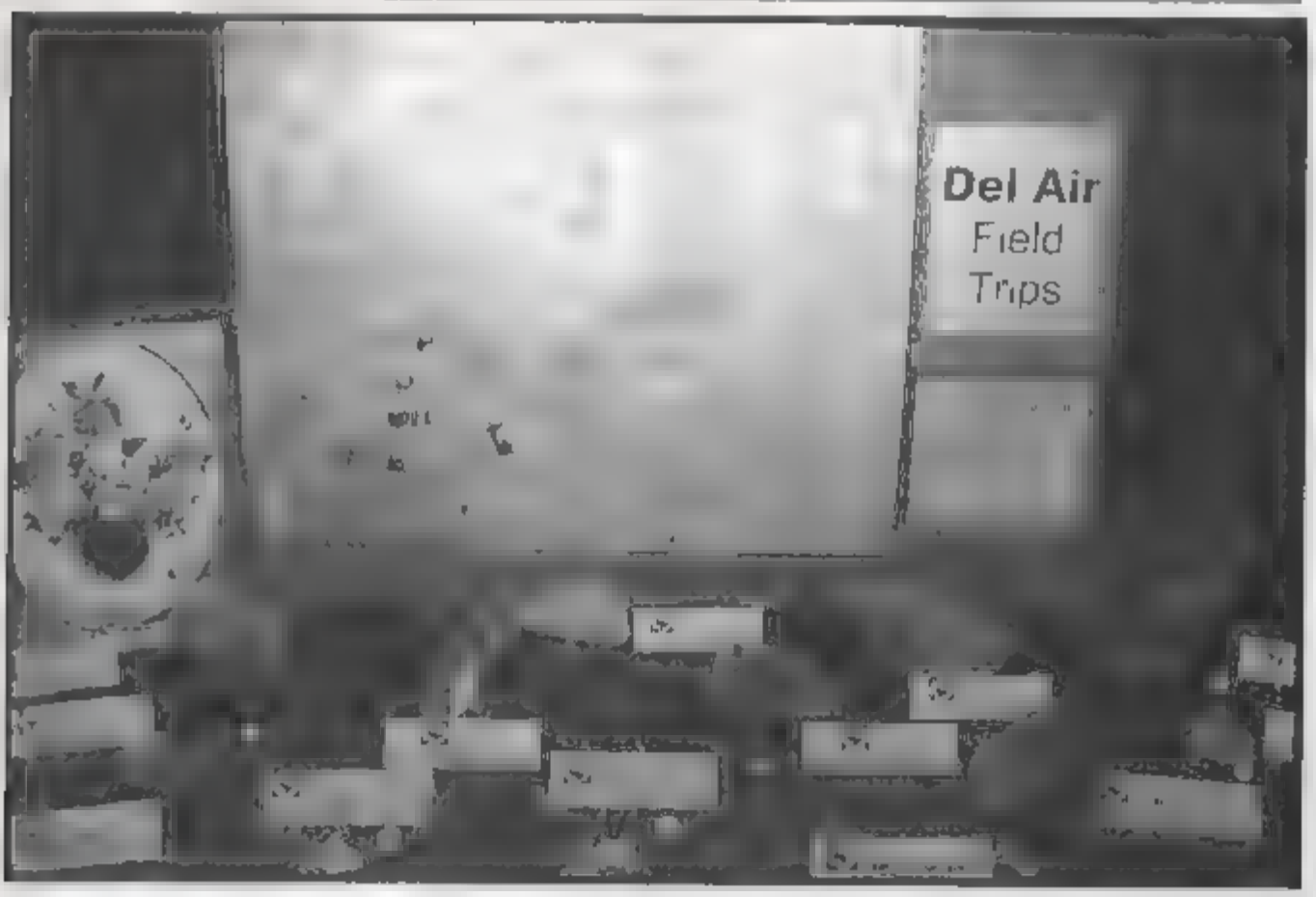


The Del Air Rockhounds Club shares a sample of the California minerals its members have collected on their local field trips. Another case (below) advertises an upcoming convention and show sponsored by the club.

That's justification enough for his statement, but David was just getting warmed up.

"Now, going down to the San Diego area ... the gem mines centered in and around Mount Palomar are probably one of the richest deposits of gem tourmalines in the country. And out of this area, we'll say in the last 100 years, several million dollars worth of gem tourmalines have come, including some of the finest specimens of gem tourmaline that have ever been produced.

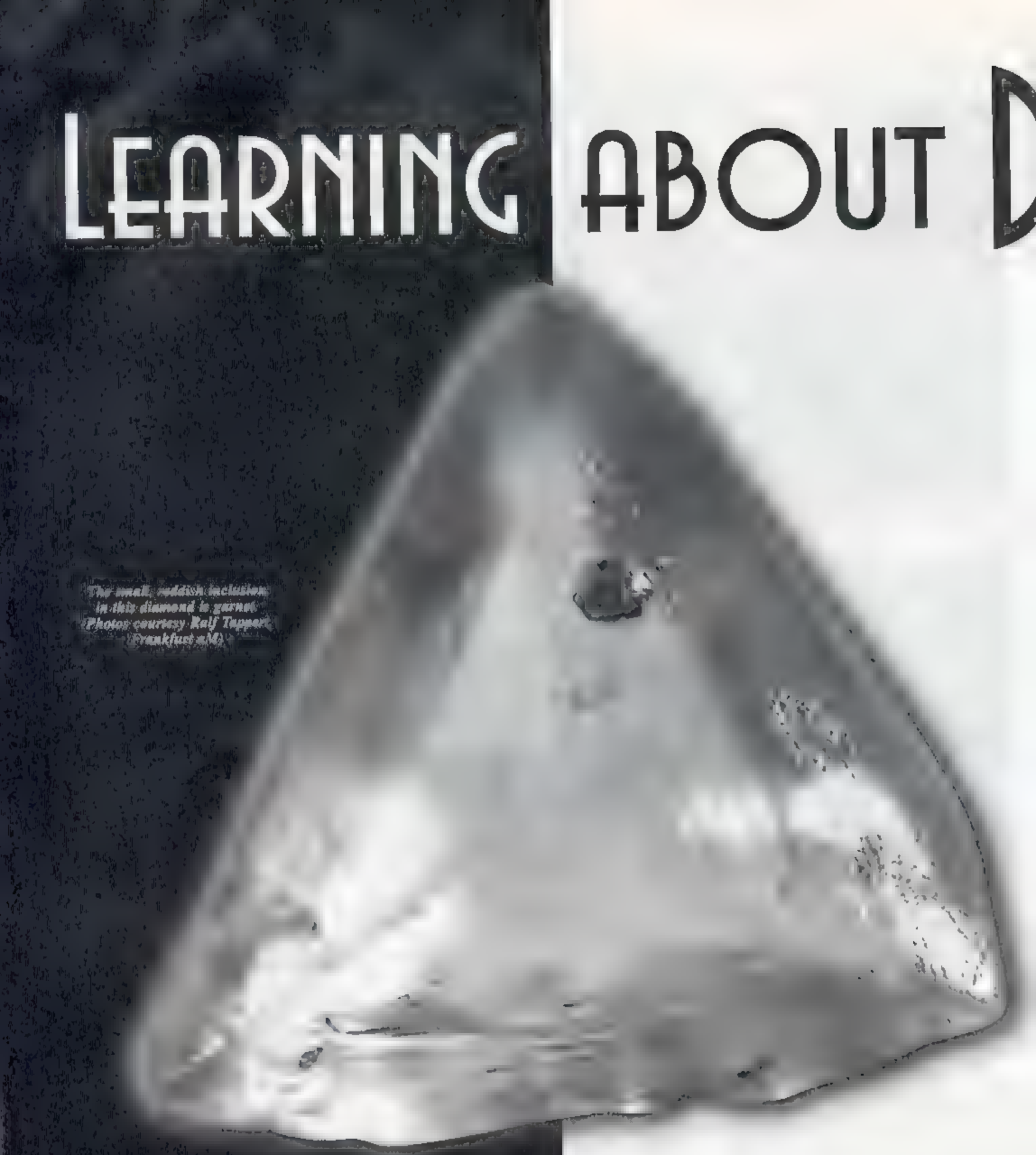
"Of course, anything that's going to produce material is under claim. And some of the mines are still working. ... The dumps of a number of these are open and available to people to go in ... with permission, of course ... and search for material. And over the years, I've known several people who've gone into that area and by sheer blind luck or whatever, have stumbled across some incredible tourmalines."

Another local site, Old Topanga Canyon, is well known for its turritella fossils. "I have seen turritella fossils out of there up to 8 inches long and an inch to 1½ inches in diameter at their base end," said David. "And these are found literally in the road cut of Old Topanga Canyon. Starting with approximately the Old Topanga Summit and working northwest form there for the next couple of miles, one can find up to 35 different varieties of fossil crustaceans in the road cut. They're easy to collect. A garden trowel or a screwdriver make great tools for collecting."

David routinely recommends two books for finding rockhounding destinations in Southern California, *Desert Gem Trails*, by Mary Frances Strong (Gem Books) and *California Gem Trails*. Information on many California sites can also be obtained from the California Federation of Gemological Societies at www.cfmsinc.org.

With so many accessible sites for rockhounding, converting rockhounds in Southern California should be an easy task. Take the time to enjoy some of these old favorites, and get converted all over again.

LEARNING ABOUT D

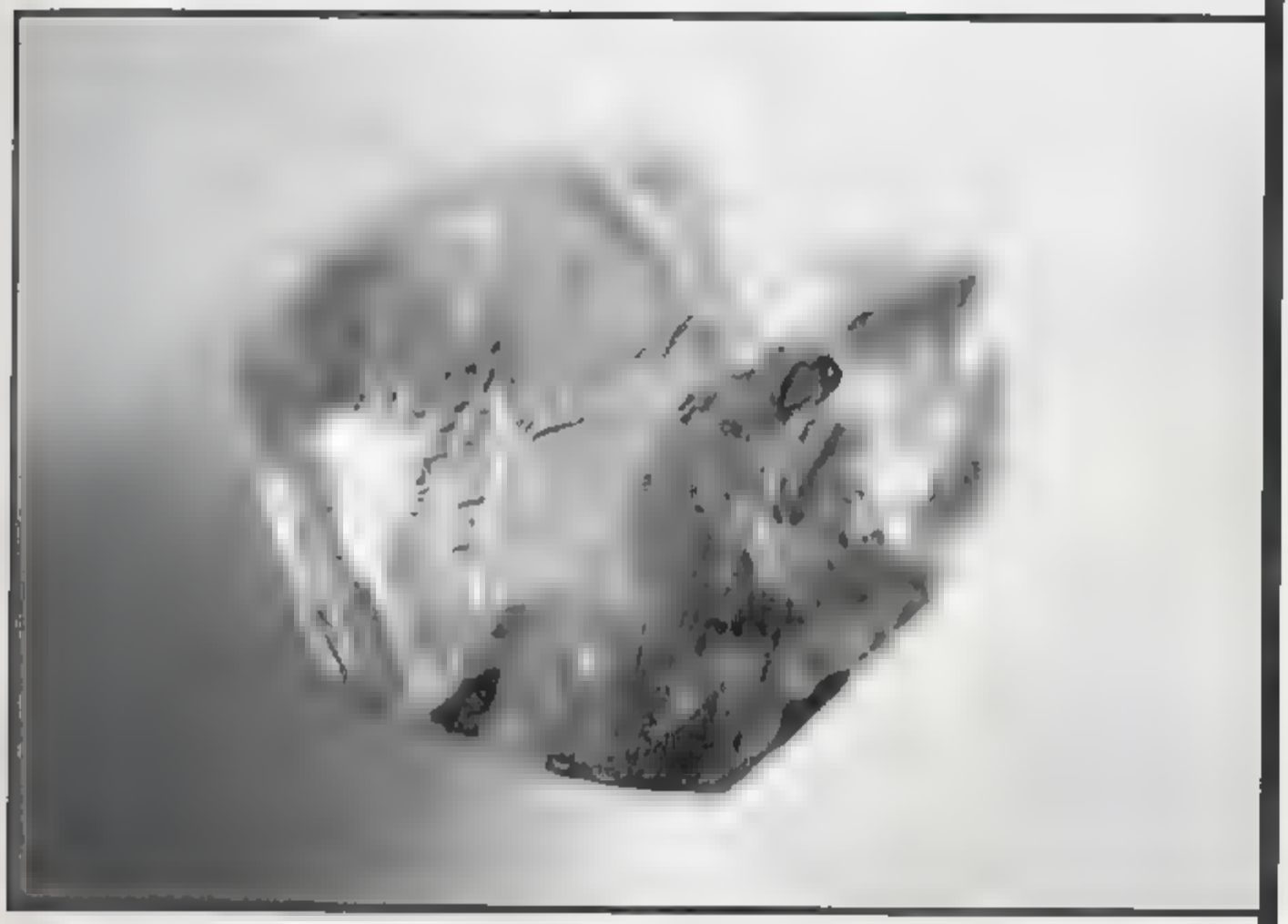


The small, reddish inclusion in this diamond is garnet. Photos courtesy Ralf Tappert, Frankfurt a/M.

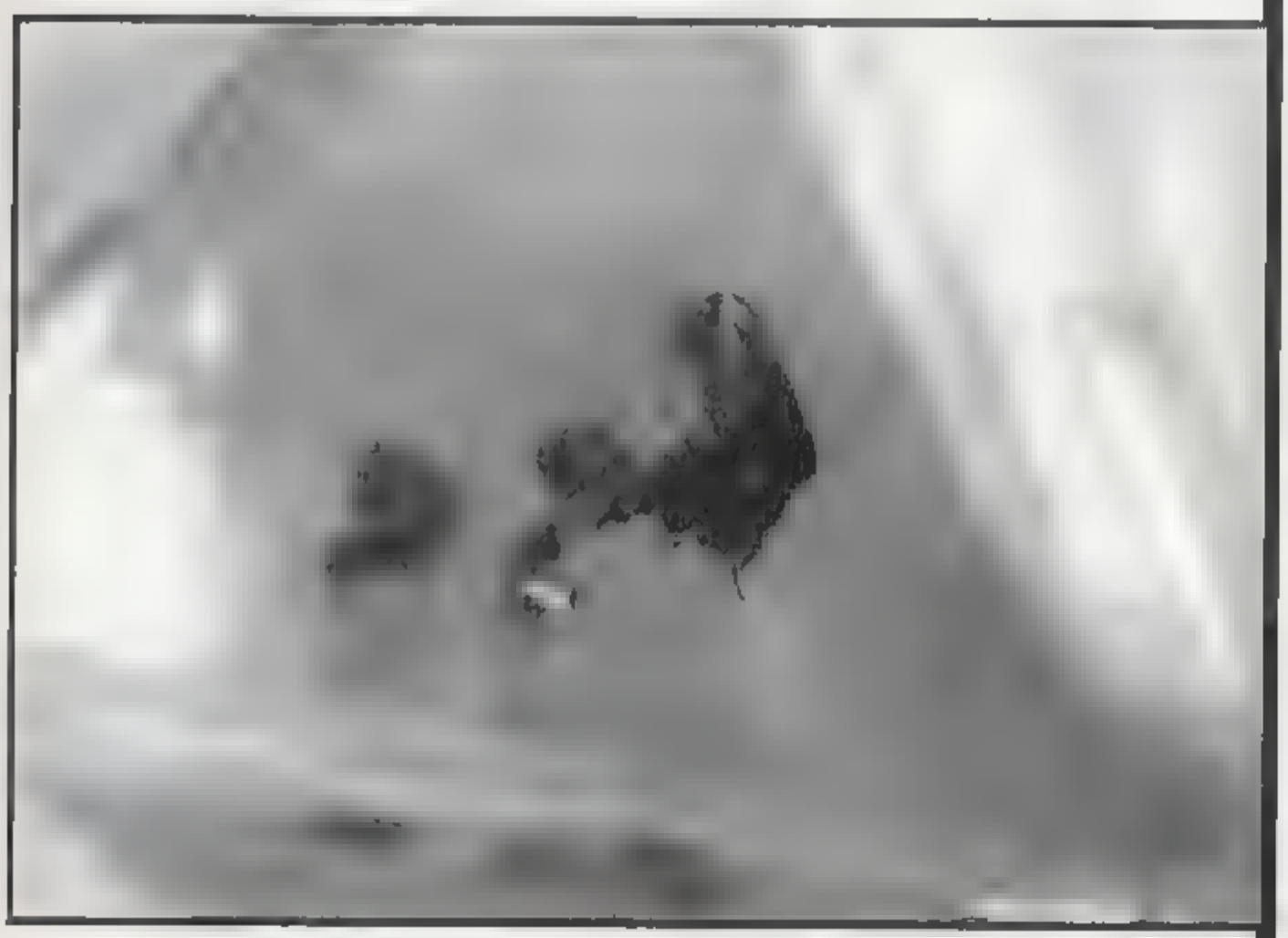
Unlocking the Mysteries of the Carbon Gem

Rock & Gem

DIAMONDS



Inclusions can be put in place during a diamond's formation or find their way through cracks after formation.



This optical image shows graphite inclusions in a diamond.

by Murray Eiland

Diamonds can be found all over the globe, from India where they were perhaps first discovered—to Brazil and South Africa. Australia produces more diamonds, including rare red and pink stones, than anywhere else, but their quality is generally low. West African nations, such as Sierra Leone, Guinea, and Angola, have significant deposits of gem-quality diamonds. Many have tried to extract diamonds from these areas, which involves considerable risk, but as the money is used to buy weapons and further destabilize the regions, such operations soon cease. Russia also has diamonds, though no one is sure how extensive the deposits are.

Most recently, diamonds have been found in Canada, which caught a number of people by surprise. There are also well-known deposits in the United States, in Arkansas (Crater of Diamonds State Park) and Colorado (near Kelsey Lake). These various localities are linked by some common threads. While diamonds can and do travel in streams, so that they are even recovered from marine sediments, it seems there are no marine origins for diamonds. The diamond sources are areas where the crust is very old—stable for billions of years—thick, and cool. In general, they are to be found in the central parts of continents; the keels of these regions plunge deep into the mantle, to depths where pressure and temperature favor diamond formation and preservation.

continued on next page

Learning about Diamonds *from page 59*

But how are diamonds formed? We get some indication of how much science has advanced from reading the classic work *Precious Stones* by Max Bauer. First published in 1896 in Germany, it was updated in 1936 to reflect the best science of the age. Aspects of general diamond classification on the basis of form and optical properties, remain much the same today.

The book discusses a number of theories regarding the origin of the diamond. Diamonds were once thought to originate from the sap of ancient plants, and for a time it was a topic of great debate whether organic carbon was transformed into diamonds at high or low temperature. By the time Professor Bauer was writing his book, diamonds from meteorites (Canyon Diablo in Arizona is an example) were known, and early high temperature experiments, many not surprisingly directed towards replicating diamonds, suggested that diamonds formed deep in the Earth. Still, no one was sure. There was not enough theoretical knowledge of mineralogy to make deductions as to what was taking place miles underground. This is where an analysis of the minerals associated with diamonds were found to be of great use.

There are a number of flaws that can decrease the value of a diamond, which is essentially pure carbon. The most common impurity is nitrogen, which substitutes for carbon in the crystal structure and yields a yellow color. Boron produces blue diamonds. Brown diamonds are the result of deformation; the crystal structure is more or less destroyed with strain.

It is possible to assign groups of diamonds to particular regions according to their various impurities. Some diamonds have brown or green spots on the surface which results from radiation damage. Radioactive minerals in the diamond bearing deposits are responsible. This is a common feature of diamonds from Brazil.

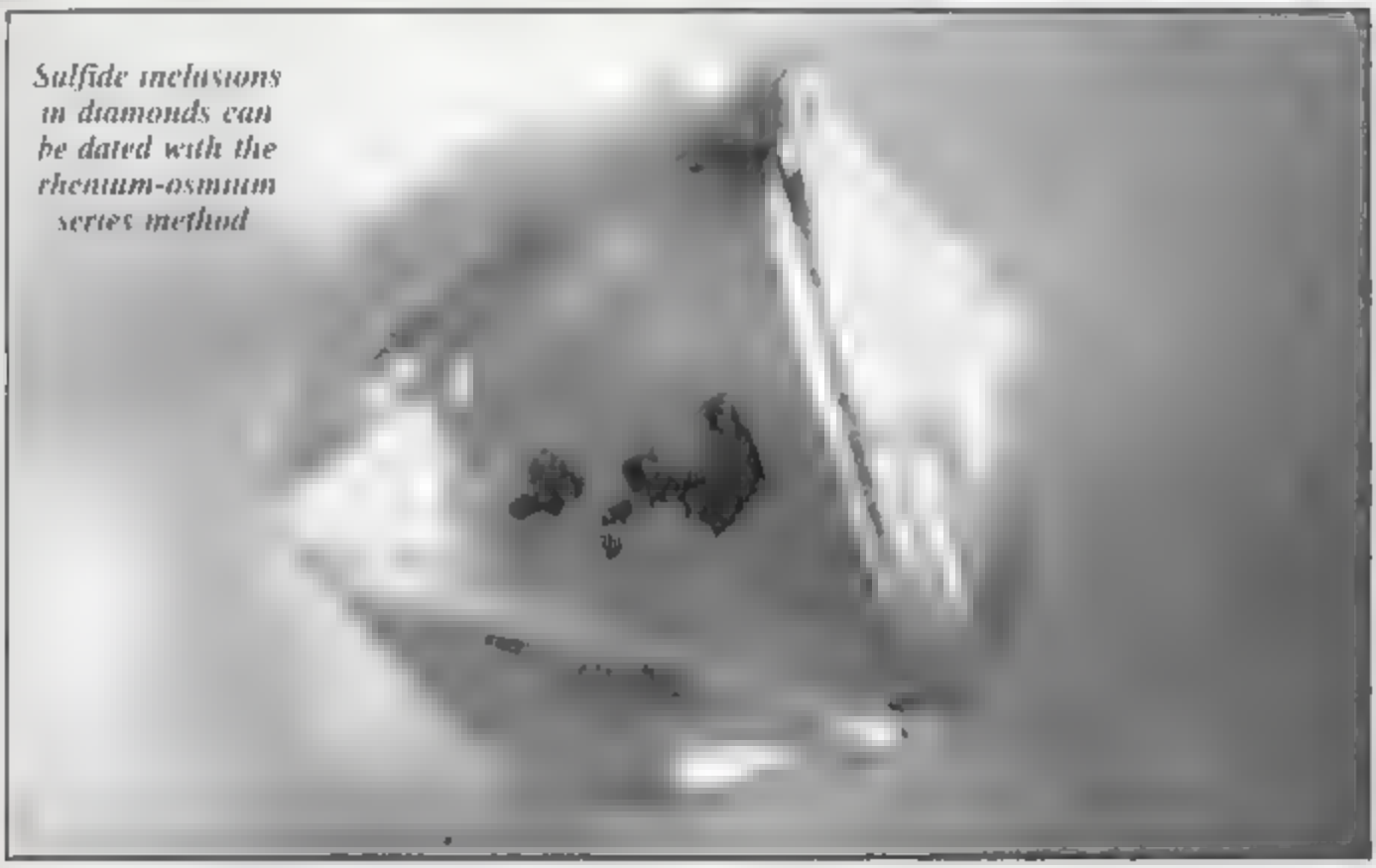
Inclusions in diamonds are also flaws, and are very important for mineralogists. At the outset, it is important to discern whether the inclusion is primary or secondary. Some minerals can be precipitated (or altered) long after the diamond has been formed. Finding a crack will answer this question, as mineralizing fluids could have entered at any time, even when the diamond was on the surface.

The study of inclusions has been possible for a long time. Before modern analytical techniques were used, they were described by eye. Modern techniques have expanded the range significantly. Diffractometers give information about the crystal structure, usually after the inclusion has been removed from the diamond. The microprobe for major elements, or a mass spectrometer for trace elements and isotopes, are powerful but expensive tools. Only major universities can afford to operate them, but such equipment is critical for answering basic questions.

Diamonds can contain graphite or sulfides, which are both seen with the naked eye as black inclusions. Black diamonds are by no means uncommon, and they can be quite inexpensive on the market. While essentially nothing can be gleaned from graphite, sulfides are more revealing. The diamond can be dated using the rhenium-osmium series method, because osmium decays at a predictable rate. Most inclusions are from the mantle (150 to 700 km), though there is still much debate about the depth at which these minerals are formed. Typical inclusions include peridotites (olivine, garnet, orthopyroxene, clinopyroxene and chromite) and eclogites (majorite garnet, omphacitic clinopyroxene, coesite and high pressure modifications of SiO_2). Small numbers of inclusions are from the lower mantle, most commonly ferropericlase and $MgSiO_3$ perovskite structure. It is in the very deepest layers of diamond formation (up to 700 km) where the real questions lie, as no one is really sure if these inclusions are typical of this depth.

Garnets from all depths are particularly interesting. Garnets can be formed from the Earth's crust, so it is possible that crust was subducted into the lower mantle at some point during diamond formation. By examining the trace elements, europium in particular, one may suggest that these rocks were formerly basalts that were born in the lithosphere (essentially the surface) and then came down into the mantle by subduction. Deep red or violet peridotitic garnet indicates that the surrounding rock was a peridotite. This is more or less the normal mantle, as most of the upper mantle is made of peridotite. Orange garnet inclusions in a diamond suggest eclogite (a rock made up of garnet and sodium rich clinopyroxene) was the host rock, which may come from the mantle or from subducted material. There are at least two models to explain this!

Obviously, by learning about the environment in which diamonds were made, one may be able to prospect for diamonds by looking at more commonly occurring minerals. Prospectors have been doing this for a long time, but essentially by trial and error. By starting from a theoretical basis, it is possible that new sources of diamonds can be found from gangue that was previously overlooked. Indicator minerals include garnet, chromites and clinopyroxenes. Very hard minerals such as these are very good for tracing diamonds, as riverine and oceanic environments cannot cast-



Sulfide inclusions in diamonds can be dated with the rhenium-osmium series method

ly destroy these species. By following the gangue to the source, almost invariably a similar structure can be found.

Because diamonds are found at great depths, they must be transported to the surface. This process must happen quickly, or the diamond will revert to the more stable graphite. Special magmas called kimberlites (an alkali-rich ultramafic volcanic rock) and lamproites (an ultramafic volcanic rock) can contain diamonds, as well as alnoites and minettes, though the latter two are not associated with quantities of diamonds.

The upper end of a kimberlite pipe is where diamonds, along with eclogite and peridotite from the depths, are found on the surface. A kimberlite is a volcanic rock from the deep layers of the mantle. Although diamonds are found in these structures, they are not created in the upper levels. Only the lower region of greater pressure is where diamonds are created. Magma acts to transport the diamonds to the surface.

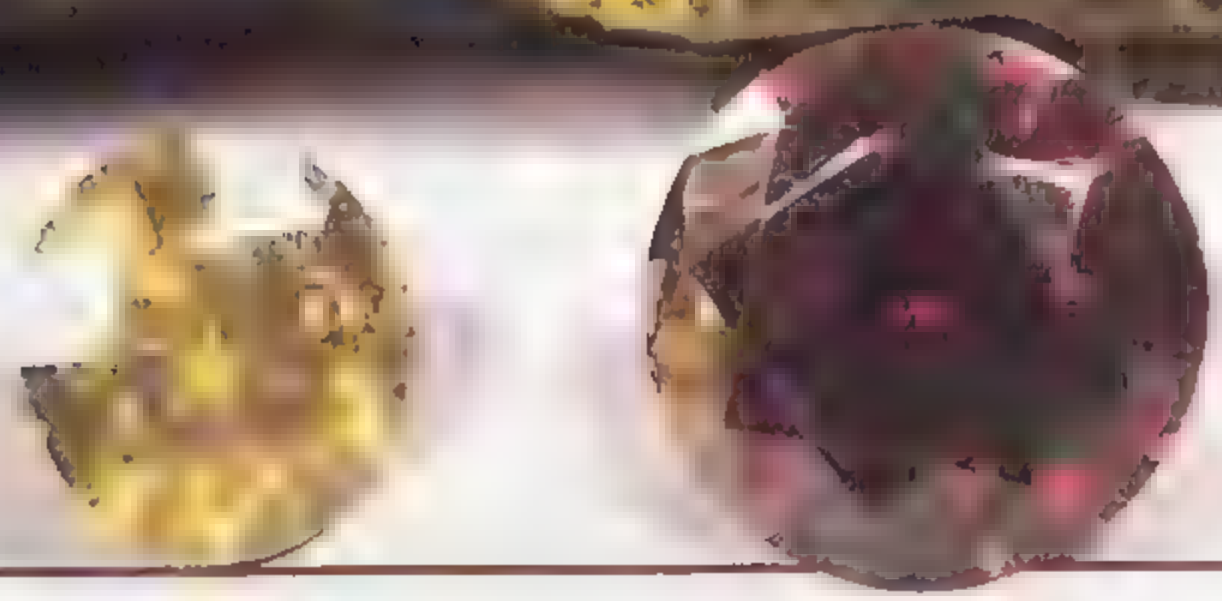
Many diamonds are rounded because they have been partially dissolved by the kimberlite melt. Nearly all diamonds formed as octahedrons, though there are also cubes, dodecahedrons and twins. No one has ever seen a kimberlite pipe erupting, but there are plenty of pipes in Africa that are about 1 km in vertical extent, tapering down to a root zone. Because of the composition, volcanologists assume that there would not be an explosive eruption in most cases. The kimberlite is very liquid, and there are different models that suggest it either seeps or burns through the crust, though as the magma approaches the surface there may be an explosive reaction with groundwater. Like the much argued phenomenon of a flood basalt, no one is sure what causes them, or what controls the eruptions. At times it is straightforward to date the eruption of a kimberlite, as it is possible to find fossils that have been made and preserved by an eruption.

There are two main types of kimberlite, but as a rule both are difficult to detect. A fresh kimberlite looks like a basalt, and when it is weathered the olivine changes to a yellow color. Prospectors refer to blue ground (from the fresh kimberlite) and yellow ground (from aged and altered kimberlite). On the way to the surface—the distance is covered in perhaps less than 24 hours—the melt collects xenoliths (material different from surrounding melt) that contain diamonds. The kimberlite can also contain very quickly grown diamonds, but the jewelry-quality diamonds are formed in the upper and lower mantle. Well-crystallized diamonds take time, but no one is sure how long it takes! A significant test would be to date inclusions on the margin of a diamond and in the core. By comparing the ages, one can suggest how long it took to grow. With recent advances in analytical techniques, it should be possible to perform this test shortly. From experiments in growing other minerals, the longer the process, the better the crystal. Some diamonds seem very old (older than 3.5 billion years), while others were formed up to about 2 million years ago.

The inner reaches of the planet are still poorly understood, as is diamond formation. Some of the most obvious questions, including what environment a diamond grows in and how long it takes to grow, are still unanswered. When one considers that artificial diamonds are being grown, it is even stranger to think that no one is sure how the "real thing" is made. With modern analytical techniques, and new models to test, it should be possible to finally answer this elusive question, and of course, finally replicate the perfect diamond. For the time being at least, nature is safe.

SULFIDES

Source of Colorful Secondary Minerals



Sphalerite comes in a variety of colors, as seen in these specimens from the University of Arizona collection. (Photos by the author)

by Bob Jones

Mother Earth is certainly a most generous hostess. Along with providing the sustenance of life on Earth, she also yields, through tectonic movement, volcanoes, and hydrothermal action, the minerals we call sulfides.

Sulfides, often thought of as massive, dark minerals and given little glory by collectors, are the primary foundation of most mining ventures. For collectors, they are the raw materials Mother Nature uses to create, through weathering, those wonderfully colorful secondary minerals we cherish.

What happens is that super hot water travels through the crustal rocks of the Earth, dissolving metals as it works its way through cracks. Sometimes it dissolves copper, lead, molybdenum, iron, mercury, and sometimes even silver or gold. Whatever elements it encounters, it can dissolve and carry with it.

As that hot water works toward the surface, it tends to cool and eventually has to drop its metallic load. When enough metals have been dropped, an ore deposit is established. That's when Mother Nature goes to work exposing, eroding, and chemically breaking down the sulfide minerals into oxides, carbonates, sulfates, arsenates, molybdates and a host of other attractive collector minerals.

So, what are these sulfides? A sulfide usually consists of one or more metal atoms joined with one or more sulfur atoms. Remember, sulfur is one of the very common elements associated with volcanoes and magma deep in the Earth. Some sulfides are simple, those made up of sulfur attached to only one metal. Cinnabar, or mercury sulfide (HgS), is a good example. The suffix "-ide," incidentally, is a chemist's way of telling you there is no oxygen involved in the structure. The presence of oxygen calls for an "-ate" suffix.

There are other sulfides in which two different metals are attached to sulfur. An example is arsenopyrite (FeAsS). Galena and arsenopyrite have no subscripts, those little numbers stuck in next to the letters of the elements. This is because the electrons that form the chemical bond that makes up the molecule of the compound are of equal value. Sulfur, like all nonmetals, can accept electrons within its atomic arrangement. Metals tend to give electrons when forming a compound. Sulfur is able to accept two electrons into its atom. Mercury can give two electrons to the formation of a molecule. So in the case of cinnabar, mercury sulfide, a one-to-one connection is possible.

Electron configurations vary from element to element, and the chemical formula reflects this with those subscript numbers. For example, it takes two atoms of copper and four of sulfur to make one molecule of chalcocite, a copper sulfide, all because nature insists on a chemical compound coming out even or balanced.

Earlier, I mentioned that sulfides are often thought of as massive, dark minerals. True, many sulfides are gray or black. And they are often massive, since nature deposits them in thick layers and veins where crystals have little chance to develop. Such deposits are very economically fruitful, but are limited in crystal specimens.

But it is equally true that sulfides can be well crystallized and very colorful. Consider such mineral sulfides as mercury sulfide-cinnabar, the arsenic sulfides realgar and orpiment (red and orange, respectively), or the brassy sulfides pyrite, pyrrhotite, millerite and marcasite. Even sphalerite, often called black jack by miners, can be a lovely red or yellow if its

ron content is minimal

Note that the colorful sulfides are always yellow or red, never blue or violet These colorful sulfides, along with their brassy and dark companions like pyrite, galena, stibnite, molybdenite, acanthite, and others, can be grouped, in theory, according to the mechanism that causes their color This is the band gap theory

The band gap theory refers to the way an atom's electrons arrange themselves Simply stated, the electrons end up in layers with gaps in between Understand that these gaps are beyond submicroscopic These gaps are barriers to the exchange or movement of electrons within the structure when electrons shift from band to band The width of the gap determines how much energy an electron needs to make the jump That energy comes from light that enters the mineral Notice that the colors we see in the colorful sulfides are at the red, or longest, wavelength end of the energy spectrum This means the shorter wavelengths, the violets, blues and greens, are being absorbed to facilitate electron movement while the longer wavelengths, the reds and oranges, are re emitted as visible color This is an oversimplification, but it gives you an idea of the mechanism involved

Cinnabar is the primary sulfide for that silvery liquid metal mercury It most often occurs close by volcanic or hot-spring ac-

Here's an interesting sulfide specimen, pyrite pseudomorph after pyrrhotite from Santa Eulalia, Chihuahua, Mexico. (Specimen courtesy Evan Jones Minerals)

tion resulting from nearby magma. Crystals develop in the hexagonal system and are usually tabular, often showing twinning, which gives them a pointed "V" shape. Until the recent Chinese discoveries, cinnabar has generally been found in crystals that seldom exceed ¼ inch. The Chinese cinnabars we now see are huge by comparison (sometimes reaching an inch), twinned, and bright red, perched on snow-white calcite

Cinnabar is also a wonderful coloring agent in other minerals Myrickite, named after the California prospector who discovered the red-banded massive gem, makes a lovely lapidary material. Cinnabar is infused in an opaline material This semiprecious gem is extremely popular in the Orient, as it resembles Chinese chicken blood stone, a much revered gemstone.

Every reader is well aware of the poisonous nature of mercury So, there is a natural fear of handling cinnabar As long as the mercury is chemically bonded to the sulfur, handling cinnabar is no major problem, as long as you don't handle it for a prolonged time and wash your hands carefully afterward. But heat it up, and watch out! In mercury mines such as those at Almaden, Spain, which has been a source of mercury since Roman times, miners have to go into a saunalike sweat chamber after each shift to rid their bodies of any mercury that has been absorbed into the body during their shift Deep in the Earth, cinnabar tends to "bleed" mercury because it's hot in those mines

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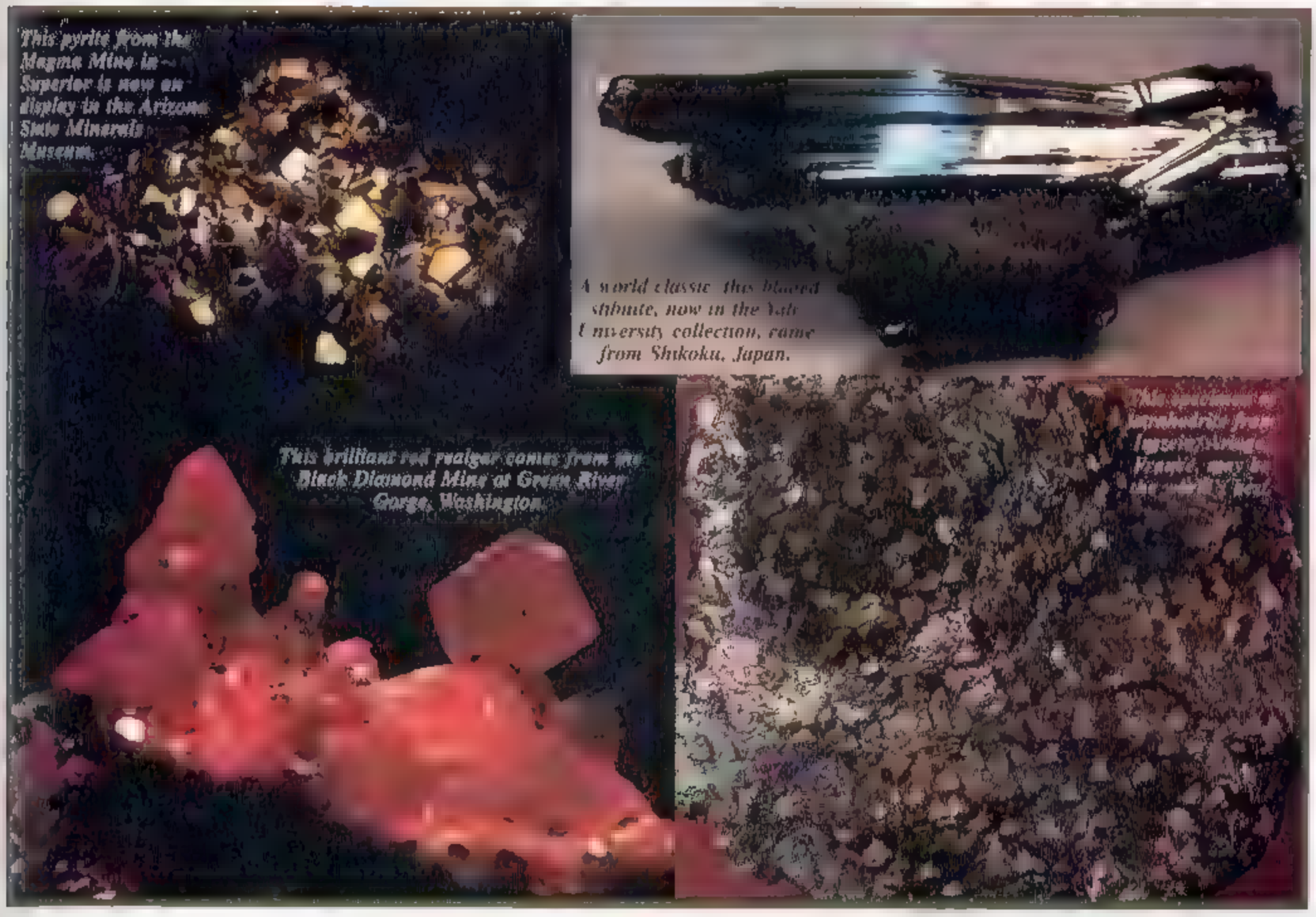


Those of you who own realgar specimens realize that, given time, the lovely red crystals begin to take on an orange tinge, even altering completely to orpiment with enough time. Look at their chemical formulae. Realgar is one atom of arsenic and one of sulfur, which hook up to form one molecule of orpiment.

Orpiment, on the other hand, is two atoms of arsenic and three of sulfur. How come? It happens that arsenic's electron structure allows for three electrons to be available to form a compound with sulfur. Only two electrons from one atom of arsenic are used. That leaves the odd electron unattached, a troublesome situation. In order for all three of arsenic's electrons to be locked into a stable structure of arsenic sulfide, three atoms of sulfur and two atoms of arsenic have to form the molecule, a molecule that is much more stable.

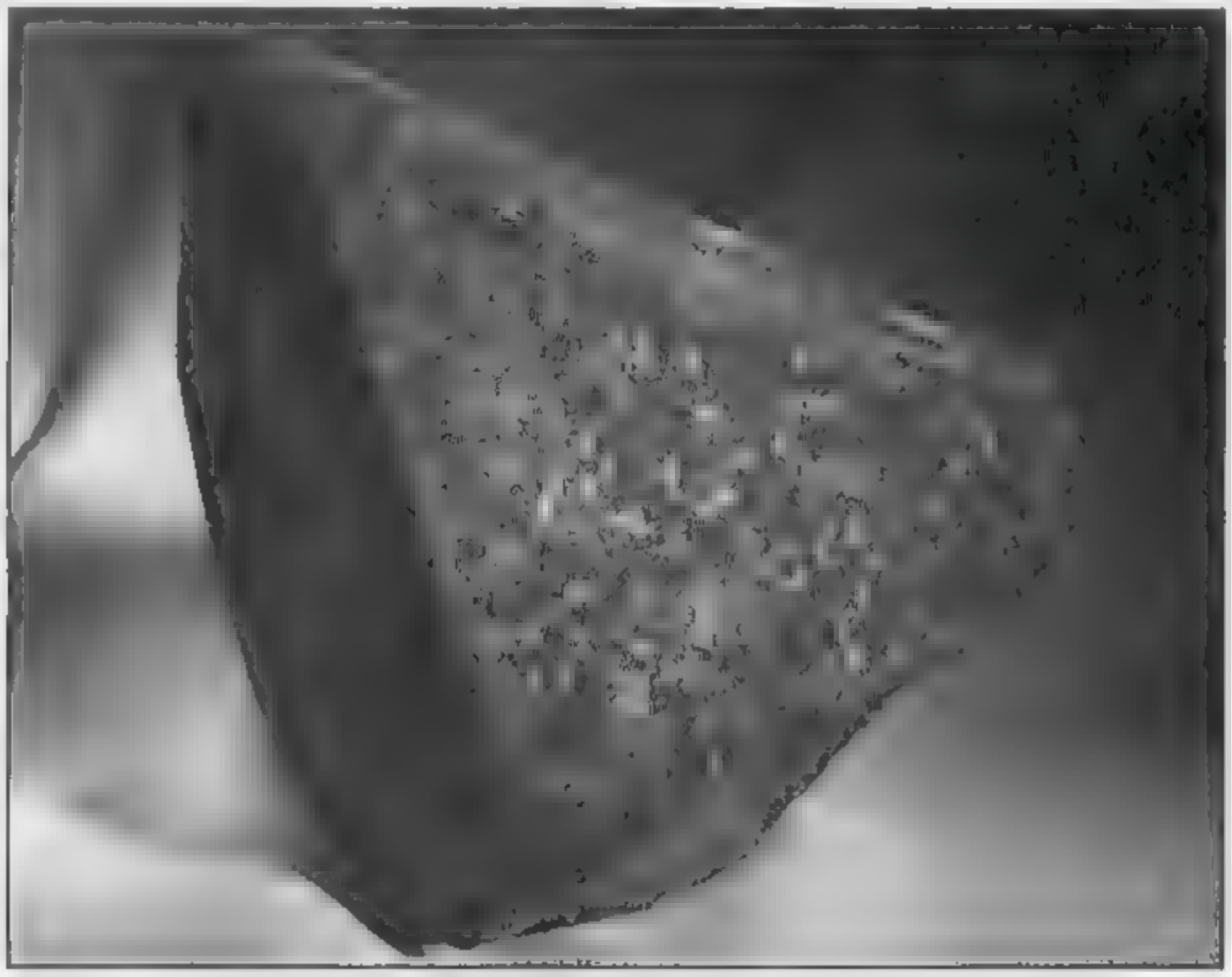
When realgar forms, it strives to be more stable so electrons start rearranging themselves using heat or light energy to do it. The result is that there is a gradual shift from AsS (realgar) to As_2S_3 (orpiment) with a resulting slight change in the band gap. Since the band gap determines which light-energy waves are absorbed, the color of the mineral changes from red to orange.

Much more popular among collectors, and the general public, are the brassy sulfides, pyrite in particular. Even gold prospectors don't mind pyrite because they finally figured out that pyrite can often contain small quantities of gold. One of the more interesting occurrences of gold can be found when the pyrite is no longer there. When pyrite is attacked by weathering, it decomposes and sometimes leaves a lovely square, hollow "cast." If the pyrite happens to harbor flecks of gold in its interior, these bits of gold get left behind and settle in the hollow spot left by the errant pyrite.

Pyrite forms in the isometric or cubic system, but is most often seen in a crystal form named after itself, the pyritohedron form. Each face of this form is five sided.

Some marvelous pyrites have come to light during the mining of other metals. In the last couple of decades, the mines of Peru have been prolific producers. And perfect cubes are commonly available from Spain. These are often found in clusters that easily separate but can be repaired to put the cubes back into their original clusters. They are very impressive.

Pyrite can be used as a source of sulfur to make sulfuric acid, but superb pyrite crystals are much more valuable. Stibnite is another member of the sulfide group. It is antimony sulfide and, like orpiment, requires two metal atoms to connect with three sulfur atoms for a stable compound.



This chalcopyrite specimen is typical of specimens from the old lead mines of the Tri-State area. (Specimen courtesy Krystalle, Laguna Beach, California.

Stibnite is a black striated mineral that forms in long prisms that are very showy and highly prized by collectors. Its crystals can reach nearly 2 feet in length or can be seen in inch long needles in diverging sprays. In any form, stibnite has been a wonderful collector mineral for decades.

The classic source of stibnite is the Ichinokawa mines of Sanjo, Shikoku, Japan. This deposit has long since been depleted, but superb small sprays of stibnite clustered on rock have long been popular from Felsobanya and nearby mines in Romania. Here in the United States, nice stibnites were found at Manhattan, Nevada, and at the Red Devil Mine in Alaska. But all these localities have been depleted.

Fortunately, China has recently become a source of wonderful prisms that rival many of the earlier Japanese specimens. The new specimens began to reach this country in 1993 and created quite a stir, for they are lustrous, striated and large, and form in superb groups and single blades like black swords. The Japanese crystals are sometimes curved. This is because the bonding along one plane is so weak that the crystals actually glide or curve. I have not seen this in the Chinese crystals, though it must happen.

You'll find the sulfide mineral argentite listed in the older literature, but not in the more recent textbooks. Does this mean there is no such mineral? Actually, no! Argentite has been described as a silver sulfide, which it is. The problem is that argentite can only exist at a temperature you sure would not want to experience, 179 degrees Centigrade. That translates to something over 300 degrees F.

What happens is that argentite does indeed form when hot hydrothermal solutions carry silver compounds into the Earth's crust. As the argentite environment cools, the mineral restructures itself and a new silver sulfide emerges. We called it acanthite. So, if you have an argentite specimen in your display you had better re-label it unless you're keeping the temperature of your display well over 300 degrees.

Sphalerite is a really interesting sulfide. First, it is the major ore of zinc. In many hydrothermal deposits, sphalerite occurs in thick, solid layers of sphalerite mixed with galena, chalcopyrite and other sulfides. As such it is usually black and massive. At the copper mines in Bisbee, Arizona, and perhaps elsewhere, sphalerite occurs as a granular ore mixed with other black sulfides. It shows a lovely orange fluorescence. The miners had difficulty distinguishing it from other sulfides until they figured out that dragging the point of a pick across the ore face would cause the sphalerite to reveal itself by sparking because it is triboluminescent.

Most familiar to collectors are those lovely little ruby sphalerite crystals that occur with galena, dolomite and chalcopyrite in the Tri-State area of Oklahoma, Kansas and Missouri. Though

hese mines have shut down, there are still plenty of specimens around One caution is to be noted here Another one of the minerals that occurs here is marcasite in lovely cockscomb crystal groups. These are great as long as you keep them away from any kind of moisture, including high humidity I've seen many older Tr.-State specimens in display cases covered with a white, powdery decay product, the result of moistare attacking marcasite. Even worse, as this white powder forms, the deteriorating specimen gives off sulfuric acid fumes which become trapped in the display case and attack other minerals on display, a ruinous situation I can recall seeing a historically important collection in Cornwall, England, in a building with a badly leaking roof Too many of the specimens were beyond identification because they were nothing but piles of powder

The sphalerites described so far have some iron in their structure along with the zinc and sulfur. Iron atoms can substitute for the zinc atoms, so the formula for this compound is often written (Zn,Fe)S. This shows the substitution process of the two metals

Because of the variation in iron content, sphalerite can be several different colors, ranging from colorless to green to brown to yellow to red. Luckily, sphalerite can occur totally iron-free. The nicest iron-free crystals I've seen have come from Franklin, New Jersey. The locals call this mineral cleiophane. It can be identified with an ultraviolet light as it fluoresces blue in shortwave light In normal light, the crystals are colorless or slighily yellowish

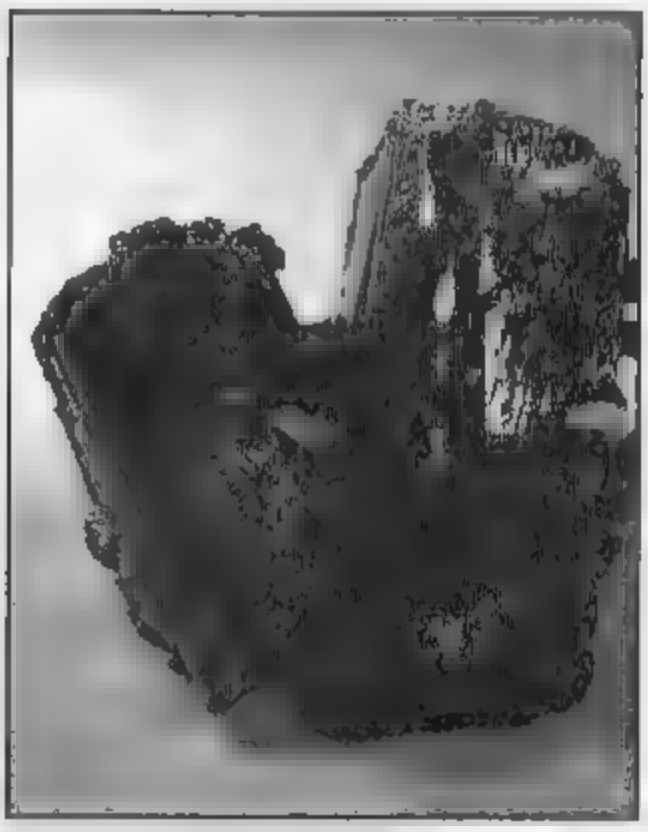
From Pico de Europa, Spain, comes fantastic yellow to red sphalerite in gemmy form The color is probably due to iron, but I am not sure This material is so gemmy it has been faceted time and time again. The hardness is Mohs 4 or a little less, not much better than calcite, so the gems are only collector gems, but they have a brilliant adamantine luster that makes them quite beautiful when faceted

Everyone loves pyrite So when you check the chemical formula for pyrite, you might compare it with pyrrhotite Both are iron sulfides Pyrite's formula is one iron atom for every two sulfur atoms to make one molecule Pyrrhotite, on the other hand, has one atom of iron followed by a 1-x along with one sulfur atom. This indicates a different internal arrangement and number of atoms involved in a molecule.

Anyone who has held a pyrrhotite crystal next to a pyrite crystal can see the external result of this difference. While pyrite is cubic, either as simple cubes or modifications of it, pyrrhotite is either monoclinic or hexagonal in form Many pyrrhotites look like stacked hexagonal discs and are very attractive

Superb pyrrhotites have come a number of localities including, but not limited to, the Morro Velho Mine in Brazil; Romania, Llallgua, Bolivia; Trepca, Yugoslavia, several localities in Mexico, and most recently, Dal'negorsk, Russia in eastern Siberia.

One of the really attractive brassy sulfides is millerite, a delightfully metallic looking nickel sulfide. It is never a major ore, but does occur at scattered localities It is found in the geodes of the Keokuk, Iowa, area and in the tiny geodes from Hall's Gap, Kentucky. The classic locality is Antwerp, New York Here it is found in perhaps its best form, diverging sprays of brassy needles several inches long. It's a pretty mineral that isn't common, nor does it occur in huge cabinet specimens suitable for a breathtaking display. But millerite is one of those minerals everyone seems to enjoy because of its hairlike appearance

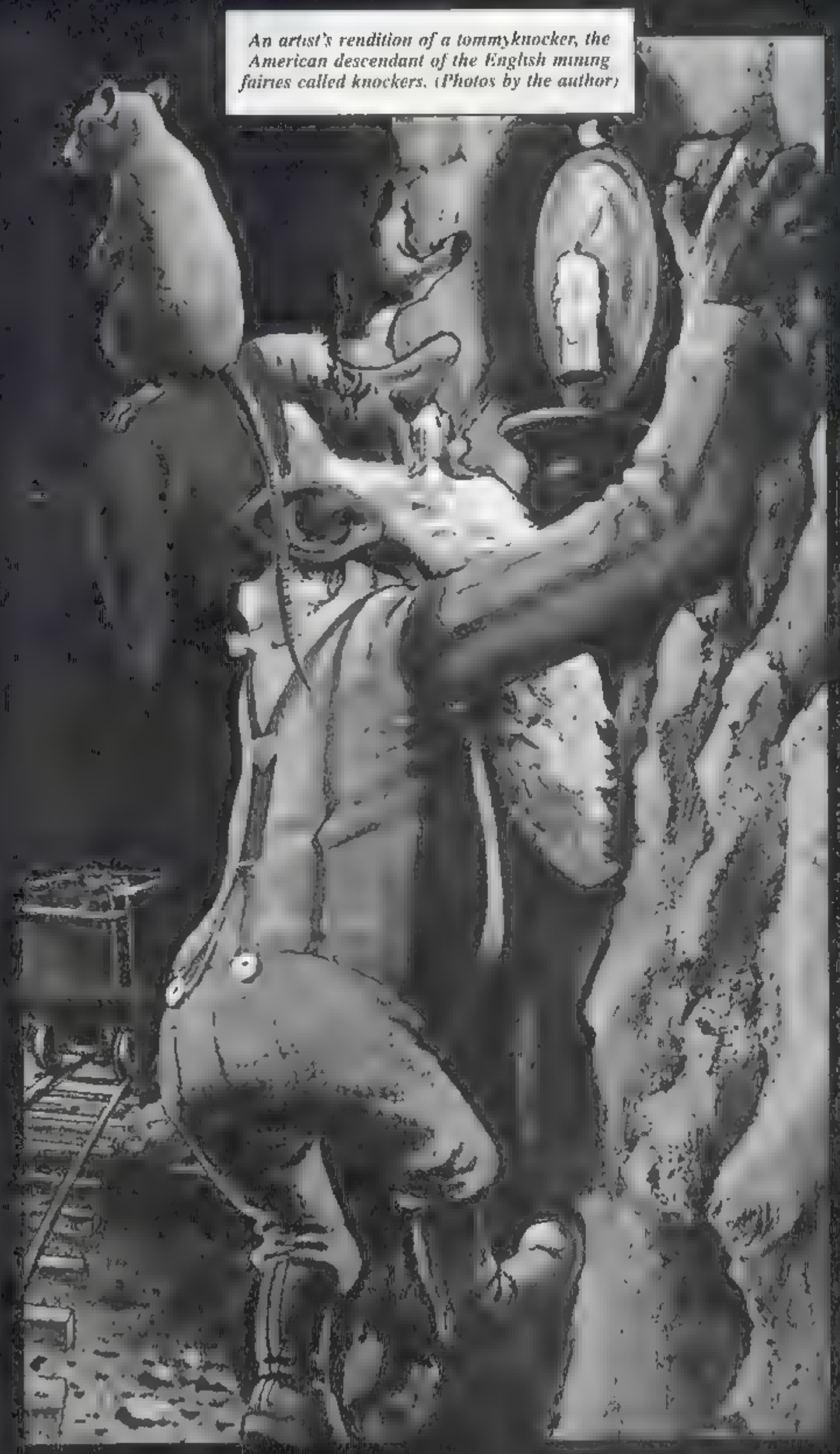


The finest pyrargyrite to come from Mexico in years, this pair of beauties stands 2 inches high. (Specimen courtesy Evan Jones Minerals)

The next time you go to a museum or view an extensive private collection, check out the sulfides. And never underestimate their importance They provide us with a vast variety of important metals through mining And when they break down, they convert to some of the world's most desirable, interesting, colorful and rare oxides, sulphates, arsenates, sulfosalts, carbonates, chromates, phosphates, tungstates and molybdates, all secondary minerals In fact, without them there would be no colorful secondary minerals for us to collect!

THE MYTHS OF

A Dark Environment Spawns a Colorful Body of Lore



An artist's rendition of a tommyknocker, the American descendant of the English mining fairies called knockers. (Photos by the author)

by Steve Voynick

Years ago, I found that becoming a hardrock miner involved a surprisingly intensive learning experience. As I learned to drill, blast and timber, I quickly realized that both the underground environment and the attitudes of the miners with whom I worked were unlike anything I had known before. After working in the underground for only a few weeks, a tragic accident occurred that introduced me to yet another side of mining—its unique folklore.

An underground muck train hauling 150 tons of molybdenite ore had derailed, pinning a miner against the side of a tunnel. Despite frantic efforts to move the heavy muck cars with hydraulic jacks, the miner died before he could be extricated. As always happened following a severe injury or fatal accident, the miners became very pensive. Several wondered aloud if the deceased miner had seen the "man with the white boots." And when the shift boss gathered our crew together to urge us to work safely for the remainder of that shift, his concluding words were, "Watch out for the 'man with the white boots'."

When I asked my partner, a veteran miner, about the references to "white boots," he explained that in the moments before a serious underground accident, the soon-to-be victim often saw a strange figure.

"He looks like any other miner with rubber wet gear, hard hat, and cap lamp," my partner explained, "but he wears clean, white boots."

THE MINES

White boots, of course, are utterly incongruous with mining. The floors of working mines usually consist of a thick mud formed by water mixing with rock particles and dust. After a few minutes in a mine, any boots, regardless of their original color, turn the color of the mud. White boots in a mine would be something that bordered on, well, the supernatural.

My partner went on to say that after the "man with the white boots" appeared, he nodded in recognition, gestured for you to come toward him, and sometimes even gave cap-lamp signals. (In underground cap lamp signals, a circular motion means "come to me," a vertical up-and-down motion means "move away from me," and a horizontal left-to-right motion means "stop.") But experienced miners knew that what he did wasn't really important. His appearance alone meant that an accident was imminent, and that it was time to get out of there — and fast.

"Did you ever see any white boots?" I asked.

"No," my partner answered. "But I've never been hurt, either."

"So do you believe it?"

"Hey," my partner answered, a bit too sharply, "I'm just tellin' you what the old-timers told me."

By the time I left that mine a year later, I had heard many miners talking and even joking about the "man with the white boots." And I'd also realized that some of the older miners actually believed that the mysterious figure existed as a harbinger of danger — and therefore that certain remnants of the ancient folklore of mining were still alive.

Folklore is a collection of traditional customs, sayings, tales, beliefs, and art forms preserved among people who share ethnic, religious, geographical, or even occupational commonalities. Occupational folklore deals with workplaces and with the legends — both simple beliefs and complex rituals — that have grown around them. Throughout history, occupations with extraordinary levels of danger and physical risk have accumulated the richest and most enduring folklore.

An enamel-on-tile rendering of Santa Barbara, the patron saint of mining.

The unusual wealth of folklore that surrounds underground mining is understandable considering the physical risks inherent to the job and the eerie, midnight environment of the mines. Much of mining's early folklore is tied to fairies, or nature spirits, mythical beings with diminutive human forms and magical powers. Fairies have likely haunted the human imagination since long before the dawn of history.

Mining folklore as we know it today goes back about 1,000 years. Early miners had little understanding of rock mechanics, ground support, and ventilation, or of other factors critical to their well-being. Nor did they have much geological insight to help them follow or intersect erratic veins of ore. It is not surprising that miners who labored in the dark, dangerous and mysterious underground turned to the supernatural, to fairies with magical powers, to quell their fears, keep them safe, answer their questions, and hopefully lead them to rich veins of ore.

Among the many mysteries of the mines were strange sounds. Working underground mines are never quiet. They echo with the dripping of water and, more noticeably, with knocking and groaning sounds created by the accumulation and release of stresses within the rock and in the timber supports. Unable to explain these sounds, and rightfully concerned by them, European mining cultures attributed them — and the cave-ins that sometimes followed — to the presence of fairies.

In the 1400s in central Europe, miners believed that malicious gnomes called kobolds inhabited the underground mines of Germany, Austria and the adjoining Slavic nations. Kobolds disliked humans and were highly territorial, always protecting their part of the underground. Miners interpreted strange knocking sounds as kobolds' warnings not to proceed in that direction. Failure to heed these warnings incurred the kobolds' wrath, usually in the form of cave-ins. The belief in kobolds gave miners a desperately needed sense, however false, of control over their dangerous environment.

Even more dangerous than kobolds were wichtlein, who haunted the mines of southern Germany and Austria. Wichtlein gave their warnings with three distinct, sharp taps. This sound was a death-knell, for it left miners only enough time to quickly make peace with their God, because none would survive the imminent explosion or cave-in.

The belief that gnomes inhabited underground mines was not limited to Europe. Chinese mythology links miners with creation. One mythical Chinese creator, who is considered the first of all living beings, is often depicted in art as a horned gnome holding a miner's hammer and chisel. In creation mythology, he lived within the Earth and hewed all things from a great block of granite — a task that required 18,000 years and ended with his death. All worldly things that he had not hewn from granite were created from his remains. The mythology is quite specific regarding minerals and geology. His blood became the rivers, his bone marrow the gemstones, his bones and teeth the metals and minerals, and his flesh the soil.

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The Myths of the Mines *from page 71*

English mining lore is particularly rich in fairies and goblins. The miners in many districts had special names for their own goblins who at different times both tormented and protected them. English mining fairies were most often called knockers because of their trademark behavior of knocking on the walls and timbers of mines. In the Middle Ages, the belief in knockers spread from the Cornish coast north to the Scottish border. Among the various districts, knockers were also known as buccas, sprigans, nickers, catty soams, dunters, and coblynau.

The Welsh coblynau are typical of the knockers, who would later become known in America as tommyknockers. Standing only 2 feet tall and appearing as frighteningly deformed men, coblynau often helped miners by knocking on mine walls to indicate the locations of hidden ore veins. But like all knockers, coblynau could also bring trouble. If miners offended them, they might cause rockfalls that could delay or even halt mine work altogether.

The mythic origin of knockers reflected the anti-Semitic attitudes that were prevalent in early England. English miners believed that knockers were the ghosts of Jews who had participated in the crucifixion of Christ, and whom God had banished to the mines. Interestingly, during the 11th and 12th centuries, many European Jews worked in the Cornish tin mines, because it was one of the few jobs open to them.

Mining folklore was widely accepted by nonminers. Because mining was a secretive profession conducted out of sight of the public, and because only miners entered the mines, the public had no firsthand knowledge about the dark, mysterious depths with which to challenge the miners' tales.

The widespread belief in mining myths is reflected in many writings of the era. Georgius Agricola (Georg Bauer, 1495-1555), whose *De Re Metallica* published in 1556, was the first serious compendium of European mining practices, was one of many writers who alluded to underground creatures. As late as 1651, *De Animantis Subterraniibus* literally "Creatures of the Underground," a treatise published in Basle, Switzerland, contained a serious discussion of the fairies, gnomes and kobolds that lived in the mines.

The names of two chemical elements even derive from mining folklore. In his *Book of Minerals*, Swiss alchemist Philippus Aureolus Paracelsus (Theophratus von Hohenheim, 1493?-1541) described a troublesome and worthless mineral found in the mines of Saxony. It was difficult to remove from valuable ores and was often associated with arsenic, which imperiled the miners' health. Paracelsus named it kobold, the German word for the troublesome gnomes that inhabited the mines. In 1735, when Swedish chemist George Brandt identified the strange mineral as an element, he gave it the name by which we know it today: cobalt.

German miners were also familiar with a dense, reddish-brown ore with spots of green coloration. Because it appeared similar to certain copper ores, they called it kupfer nickel or "devil copper," nickel being the German word for "deceptive little spirit," another allusion to the gnomes of the mines. When Swedish chemist Baron Axel Frederic Cronstedt finally identified the mysterious element in kupfer nickel in 1771, he honored a two-century old tradition and named it nickel.

Miners turned not only to imaginary kobolds and knockers to help them cope with the uncertainties of the underground, but also to religion, adopting Santa Barbara as the patron saint of mining. Although the persona of Santa Barbara emerged in Europe in the 7th century, her historically unverified origin goes back to a 3rd-century Roman provincial capital in what is now Turkey. Barbara's father, Dioscorus, a wealthy nobleman, sequestered her in a tower to protect her, and was furious when a tutor converted her to Christianity. After Barbara refused to renounce her new faith, the Romans tortured her and sentenced her to death. Dioscorus took his daughter's life with his own sword. Dioscorus was then struck dead by a bolt of lightning from heaven.

According to the *New Catholic Dictionary*, the tale of Barbara's life and death was probably composed during the 7th century. Nevertheless, by the Middle Ages, Barbara had become a revered saint, especially in German mining communities. By 1346, the silver mining town of Freiburg had no fewer than 60 altars dedicated to Santa Barbara, who was by then accepted as the patron saint of mining in all of Christian Europe.

Barbara's tie to mining is vested in the lightning bolt with which God supposedly avenged her death. Black powder explosives were already used in mining in the 1300s. Like lightning bolts, black powder explosions were accompanied by flashes of light and thunderous noises. And when improperly or carelessly used, black powder could smite a miner every bit as well as the lightning bolt smote Dioscorus. Not surprisingly, Santa Barbara also became the patron saint of artillery men.

Santa Barbara is often portrayed surrounded by the symbols of her life: a tower, a sword, and lightning bolt. In mining contexts, she is shown floating on clouds, with miners, hoists, ropes and ladders below. Artists widely depicted Santa Barbara in paintings, copper engravings, woodcuts, stained glass windows, altars, and sculptures. In Latin America, many mines and mining towns are named in her honor, and miners often place simple wooden or plaster statures of Santa Barbara at mine entrances to ask her blessings in their work.

When Cornish miners, along with miners from Italy and Central Europe, arrived in the American West in the late 1880s, they brought with them their beliefs in gnomes, kobolds and knockers, the latter being rechristened tommyknockers. Like

The death of a haulage animal in the underground was thought to foretell the death of a miner.

their Old World descendants, tommyknockers did not like to be seen by humans, and the unfortunate miners who unexpectedly chanced upon one received the thrashing of their lives. This partly explains the tradition of placing a small clay figure of a tommyknocker at mine portals and shaft collars. The effigy served as a good-luck charm, and also as a warning to visitors.

To illustrate this point, consider an old tale about a coal miner who befriended the tommyknockers. Because the tommyknockers helped him in his work, the miner always achieved the highest production in the mine, yet never seemed to tire. To figure out how he managed this, the other miners quietly followed him into the mine one night. They found him asleep, while a team of tommyknockers wearing tall, red hats performed his work. But when the tommyknockers realized they were being observed, they brought the entire mine down, killing everyone inside.

continued on page 74

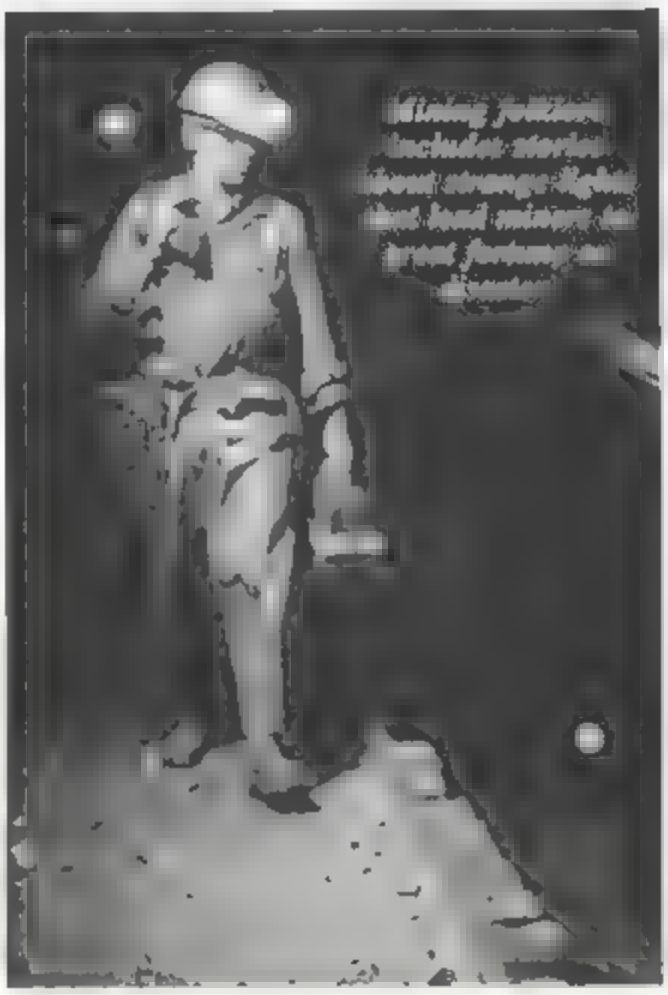
The Myths of the Mines *from page 72*

Lights also play a part in mining folklore. Light has a profound impact on the psyche of miners, simply because it is the antithesis of the complete underground darkness. Whether the sputtering flame of an oil lamp, a flickering candle, or the dancing, blue-white jet of light from a hissing carbide lamp, miners' lights have always exuded a certain eeriness. In the underground, active imaginations easily conjure visions of fantastic lights where none exist.

Tales from mines in both Europe and the American West tell of strange underground lights that have warned of impending disaster, guided miners to rich ore veins, and lured miners to disaster. Unexplained lights, real or imagined, easily became the ghostly cap lamps of deceased miners' signals from a supernatural world. In the Peak District of England, miners in the 1800s told of the "fiery drake," a mysterious dancing blue orb of light that guided them to the richest ores.

Even in modern mines where miners wear relatively bright reliable electric cap lamps, light can create ghostly effects. Water on mine walls or in pools on floors can act as prisms and mirrors, reflecting and refracting light long distances, even around the bends of tunnels. Although no direct light source is visible, miners sometimes see ghostly plays of light that seem to defy explanation.

Animals are also a part of mining folklore. Until the early 1900s, mules were used for underground haulage. Many miners believed that a mule's death in the underground was an omen that a man would be next. While mine managers typically worked haulage mules to death, they always tried to return the animals to the surface before they died, simply to avoid the demoralizing effect that an underground death would have on the miners.



Rats were commonplace in many mines, and miners interpreted the rodents' continuous activity as a sign that all was well. But if the rats suddenly departed an area, some miners would refuse to work in that section of the mine.

Many miners adopted rigid habits, believing that their regular pattern of work, rest and eating was somehow responsible for their safety. Some would eat the same lunch in the same place for years, fearing to break the pattern that supposedly kept them safe.

Even in recent decades, miners have believed that women entering the underground brought bad luck, a fear that originated over many preceding centuries when few if any women ventured underground. But however deeply ingrained, that bit of folklore faded away quickly, at least in the United States, when women began working as underground miners in the early 1970s.

Mining folklore probably reached its peak in the early 1700s. By then it had already grown into a complex system of beliefs and rituals that were never questioned. It began a gradual decline in the mid-1700s, with the rise of the Age of Science, the death of alchemy, and the emergence of a logical understanding of the natural world. Scientific revelation was clearly at odds with traditional mining folklore. Nevertheless, that folklore would survive, primarily among ethnic and religious groups, and largely because of the dark, dangerous, and ever-mysterious nature of underground mining.

Today, however, the folklore of mining, at least in the United States, is rapidly fading. One reason is that the ethnic and religious enclaves that were strongholds of mining folklore and were once common to all mining camps have broken up and scattered. Other reasons include higher educational levels and a general acceptance of science among working miners. Most miners today have at least some college education and a technical and scientific awareness that their predecessors lacked — a background hardly conducive to nurturing old folktales.

Nevertheless, the tale of the "man with the white boots" survives as a modern manifestation of 1,000 years of mining folklore, and a reminder of how miners once coped with the dark, dangerous, and mysterious world of the underground. More than a whimsical figment of miners' imaginations, it is a surviving remnant of long centuries of belief in wichtlein, kobolds, tommyknockers, and a patron saint short on historical veracity.

During the time I worked as a miner, I never saw the "man with the white boots," and I don't believe that he exists. But sometimes in those dark drifts when the overhead rock groaned a bit too loudly, I may have taken a quick look over my shoulder — just to be sure.

ROCK SCIENCE

by Steve Voynick

Iridium and the K-T Iridium Layer

For a rare metal that most folks have never seen, iridium has gotten a great deal of media attention over the past 20 years. The reason is not iridium itself, but the unusually high concentrations of the metal found in a 1-centimeter-thick (½-inch) stratum within sedimentary formations almost worldwide.

What makes this thin stratum notable, apart from its high content of iridium, is that it precisely marks the stratigraphic boundary between the Cretaceous (K) and Tertiary (T) periods. This stratum has become known as the 'iridium anomaly at the K-T boundary,' or simply the "iridium layer."

Along with platinum, palladium, rhodium, ruthenium and osmium, iridium is one of the platinum-group metals. Physically similar to platinum, iridium has a very high density and a metallic luster that is silvery white with a slight yellowish tint. Its low chemical activity gives it the greatest corrosion resistance of any metal.

Iridium is very rare, with sedimentary rocks on average containing less than two parts per billion of the metal. Only a few tons of iridium are recovered each year as a byproduct of mining platinum, palladium and nickel ores. Iridium is used as a catalyst, to manufacture specialized electronic components and laboratory crucibles, and as an alloying agent with platinum. Commensurate with iridium's noble properties is its noble price: about $500 to $600 per troy ounce.

Earth scientists began focusing their attention on iridium in 1980, when Nobel Prize-winning physicist Luis Alvarez and his son Walter, a geologist, analyzed clay samples taken from a K-T boundary site in Gubbio, Italy, and found iridium levels 100 times above the crustal average.

Because iridium, while rare on Earth, is hundreds to thousands of times more abundant in extraterrestrial bodies, Luis and Walter postulated that the K-T iridium layer originated as atmospheric fallout from an enormous dust cloud generated by the cataclysmic impact of an iridium-rich asteroid or meteor. They also suggested that this impact caused the K-T mass extinction, when the dinosaurs and 75 percent of all species of life on Earth were wiped out.

During the 1980s, other researchers analyzed samples from K-T boundary sites on different continents, always finding high levels of iridium to support the Alvarez impact theory. In 1991, geologists finally found the "smoking gun"—a large, deeply buried impact crater dating precisely to 65 million years—beneath Mexico's Yucatan Peninsula and the adjoining Gulf of Mexico. Most researchers now agree that the impact that created this crater, named the Chicxulub (CHICK shoo-loob) Crater, had generated worldwide clouds of dust and debris, fallout from which formed the K-T iridium layer.

Recent research has identified two other indicators of catastrophic asteroidal or meteoric impact. In a thin substratum immediately below the iridium layer at several geographically dispersed sites, researchers have found high levels of carbon. Isotopically uniform, the carbon appears to have been derived from a single global fire event.

Another iridium layer impact indicator is "shocked" quartz, tiny quartz crystals that have been deformed by extreme pressure. The extraordinary pressures needed to cause shock metamorphism in quartz can be generated only by nuclear explosions, special laboratory methods, and meteoric impacts.

Paleontologists and geologists now accept the impact theory to explain the origin of the K-T iridium layer. But not all agree that the Chicxulub impact was the direct cause of the K-T mass extinction. Opponents of the impact theory suggest that the extinction was really caused by related cycles of global warming and cooling, atmospheric changes, or even massive volcanic activity triggered by the enormous impact shock.

The key to settling that debate may be in learning how much energy was released during the impact that formed the Chicxulub Crater. To hopefully answer that question, an international deep-drilling project has recently completed a year-long effort to collect 5,600 feet of core-drill samples of the Chicxulub Crater. Analysis of these samples may reveal whether or not the Chicxulub impact caused the K-T extinction of the dinosaurs—a finding that will be the subject of a future column.

The Utilitarian Precious Metal

Superb wire silver from one of Mexico's most prolific mines at Guanajusto. (Photos by the author)

Silver Shines for Everyone

by Bill Evans

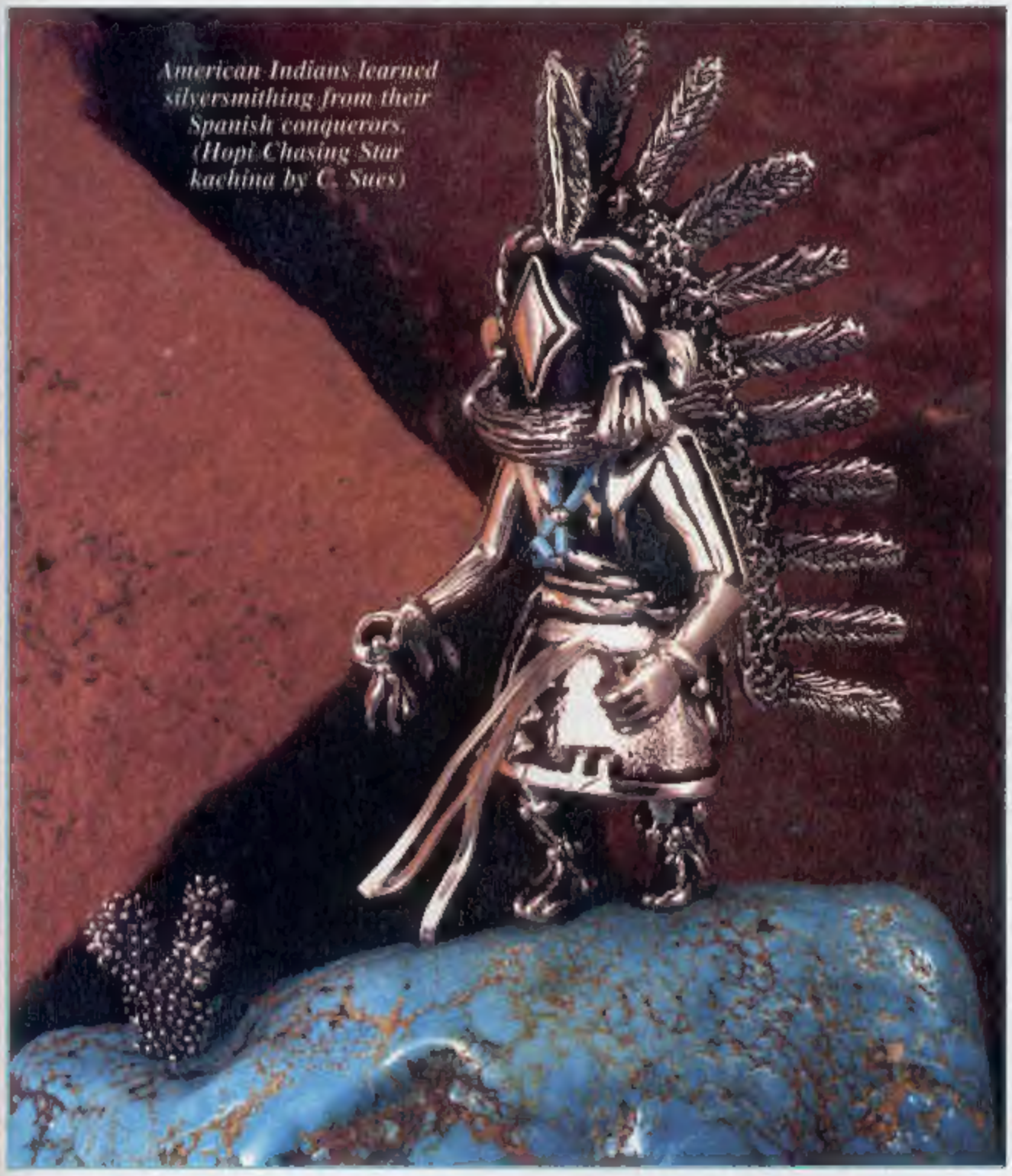
Certainly the most commonly used of the precious metals is silver. Gold is more valuable, and because of its lovely yellow color, more attractive to most people. And if we each had a choice between finding one or the other when prospecting, I'm afraid silver would come out second best. But in the grand scheme of things, silver is far more functional, far more universally used, and much more readily available to the average person than is gold.

It may surprise you to know it has not always been that way. Back in the days of King Tut, silver was far more valued and considerably more rare than gold. Just consider what was found in Tut's tomb. You can almost hold the amount of silver found there in one hand. There was a dagger handle and some overlay work on Tut's gold-encrusted wooden throne. And that's about it. Compare that with the seven *tons* of gold employed to eulogize the boy king! In

those days, silver commanded a price about 20 times that of an equal amount of gold!

A couple of factors put silver in the hands of every person while gold continued to hold its more regal status. The big reason silver gradually fell in value as compared to gold was both a matter of function and a matter of availability.

to begin with and alloys quite readily. Imagine making a coin representing 10 cents. Make it of gold, and it would get lost in your pocket. So, for very practical reasons silver became much more commonly used than gold. After all, not many people could afford gold coins to conduct very ordinary business!



American Indians learned silversmithing from their Spanish conquerors. (Hopi Chasing Star kachina by C. Sues)

In Tut's day, gold was actually easier to obtain than silver because gold occurred as a natural metal that could be panned or mined. Silver, on the other hand, does not occur very often as a native metal. It is more chemically active than gold, so it combines to form compounds that, in those earliest days of mining, could not be easily treated because smelting was at best a primitive process.

With advances in metallurgy, along with the ability to recognize silver-bearing minerals and the skill to smelt them, silver became much more abundant and more readily available, and hence, its value dropped when compared to gold.

Keep in mind that in the development of coinage, it might be more impressive to have coins of gold, but silver is harder than gold, so it is less easily worn away. One of the problems with gold coins is that after much use they no longer weigh what they originally did. Of course, with alloying, gold can be hardened. But silver is harder

This Ram's Horn silver specimen is unusual for the Cobalt region, once Canada's richest silver district.

Perhaps the first great surge in silver production came with the discovery of huge silver deposits at Laurium, Greece. Granted, the silver was locked in combination with other minerals, but it was easily extracted. Gold, on the other hand, was not found in quantity in Greece, so silver was used by default. The result was that a huge (by the day's standards) flood of silver hit the market as the Greeks not only mined the silver, but used it to construct a huge fleet that defeated the Persians in the battle of Salamis in 480 B.C. Thus silver became the metal of commerce, while gold continued its "noble" ranking.

The Romans were just as eager to mine and use silver. Their mining activities on the Iberian Peninsula brought forth both gold and silver aplenty. There weren't any huge gold strikes after the fall of the Roman Empire, but by 1000 A.D. some very rich silver strikes were made in the Erzgeberge and Harz mountains of Germany. The quantity of silver surged dramatically again, and the metal experienced an even broader functional application, especially in coinage.

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This remarkable silver from Kongsberg, Norway, sports a tiny calcite crystal.

The Utilitarian Precious Metal *from page 81*

On the specimen scene, there are few, if any, examples of Laurium silver around. Other Laurium minerals, some of which formed when the slags from mining were dumped into the ocean, are around today in minor amounts, but where is the native silver? It wasn't until the German mines began to flourish that wonderful silver specimens were not only found, but also saved. Even today we find superb German silvers in museums and private collections. Some of them even find their way into the public domain, where collectors have a chance to buy them.

The next great silver discovery occurred in Norway. In fact, silver specimens from the Kongsberg mines are universally considered the finest examples of native silver ever found. It all happened quite by accident. There is evidence that a number of silver prospects were being worked by locals long before the "official" discovery of the Kongsberg deposits in 1623.

In that year two youngsters were tending their animals on the slopes overlooking their village. One of the animals—either a goat or sheep—was sharpening its horns on a rock outcrop. The action revealed a bright, shiny metal interior. The kids, Jacob Grosvold and Helga Verp, took samples home, and their folks began to extract and sell the metal. The problem with this was that the king had decreed that any metals found were his. The result was that Arne Verp, Helga's father, was arrested for theft when he tried to sell silver he had mined. So, he had a choice of revealing his source or going to jail. Shortly after, Grube (mine) Kongens opened. It became one of the most productive of the several hundred mines and shafts that eventually opened here. Another mine in the area has a name I particularly like. It was called Gottes Hulfe in der Noth. That translates to "God's Help in Distress"! The last of the Kongsberg mines finally closed in 1957.

In those 300-plus years of mining, the Kongsberg area produced 1,350 *tons* of silver, according to Ole Johnsen, who wrote the definitive reference on this district. His book, which I used for this article, is *The Silver of Kongsberg* (Bode, Westfalen, Germany, 1987), a superb reference full of factual and useful information. I urge you to obtain it!

The beauty in Norway silver lies in its three different forms. Much of the silver was simply massive chunks and flats that were mined in huge amounts. The most common, and certainly most attractive, Norwegian silver specimens are the twisted, curling wires, some as delicate a human hair. Others would be more appropriately called "cables," as they can be as thick as your forearm or your leg and almost as long. These monster wires can be seen in the Museum of Mining in Kongsberg.

The least common form of silver from Kongsberg is the sharp cubic crystals, arrowhead twins, herringbone twins, and silvers associated with calcite, fluorite and even a few silver sulfosalts. Luckily, because mining persisted here for so long and so many fantastic specimens were found, the silvers of Kongsberg are the standard against which all other silvers are compared—and usually come out second best.

Here in America, the earliest serious strike of this highly conductive metal was actually a byproduct of copper mining. Long before Europeans came to this land, Native Americans mined copper in what we now call the Upper Peninsula of Michigan. I know of no evidence that those people worked the silver, but Michigan copper trinkets, utensils, and trade goods have been found all over the continent.

In 1844, these rich deposits of two native elements were finally revealed to the world through the work of Douglass Houghton, though French missionaries and explorers were well aware of the copper in this region. Following the publication of Houghton's work, a huge rush occurred. It wasn't long before finely crystallized copper specimens, often combined with crystallized silver, were finding their way into the homes of miners and the hands of collectors.

One of the very interesting side issues that emerged in the Michigan copper mines was the constant tug of war between owners and miners over the silver specimens. The mine owners claimed the silver was as much an ore as the copper and should go to the smelter. There was a practical reason for this, as well as a greedy one. Silver is an even better conductor of electricity than is copper. So a little silver added to copper wire makes it a better conductor. This made the copper from Michigan the premier copper sought by the electrical industry, for which they paid a premium price!

The miners, on the other hand, claimed they were being paid only to mine copper. Any other metal, such as silver, was inci-

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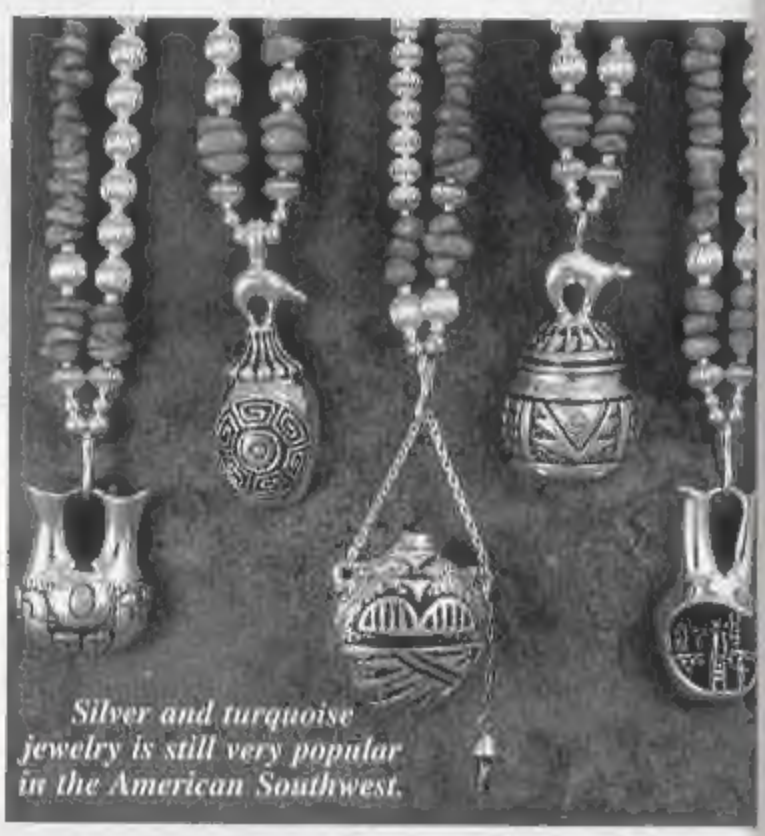

Silver and turquoise jewelry is still very popular in the American Southwest.

dental and was theirs by default. So, a host of silver specimens came to light in the lunch pails of miners and they either saved them or, more often, reduced them to crude bars to be sold as a wage supplement.

Today these mines are closed, but their memory is locked in forever, for attractive copper and silver specimens are still common in collections and displays all over the world. The best examples are in the A.E. Seaman Museum at Michigan Technological University in Houghton.

The Michigan silvers are entirely different from those from Kongsberg or Germany. They are beautifully, though sometimes crudely, crystallized and are often perched on well-crystallized pieces of copper. Many are slightly rounded but sharp dodecahedrons. Cubes are much more rare, and lovely herringbone-twinned crystals are prizes worth having.

When the Spaniards came to the New World, they sought gold. They found it, but mostly in finished form. More importantly, they came upon one of the richest silver provinces in the world: Mexico. By the time the Spaniards, and later a free Mexico, reached a zenith in silver production, fully half of all the silver being mined in the world was coming from Mexico. It is estimated that about one-fifth of all the silver ever mined and in use has come from Mexican sources, and they are still producing!

Practically all the silver coming out of Mexican mines is in the form of a silver compound. They have also produced some of the world's great silver-bearing minerals. Rare species like pearceite, polybasite, stephanite, acanthite, chlorargyrite, proustite and pyrargyrite have been encountered again and again.

Of these pyrargyrite is the most common these days. Some almost brutish, but sharp and lustrous, crystals have come to light of late. The mines producing these 1- and 2-inch blocky crystals are Fresnillo and St. Martin, seemingly on the same trend in the state of Durango. Both are the classic replacement-type deposits, in which hydrothermal solutions have attacked and dissolved limestone to make cavities in which fine crystals can develop. Some of the pyrargyrites are over an inch thick. All show the flash of red in transmitted light, but look almost black otherwise.

On one trip to San Martin and Fresnillo years ago, I spoke to a mining engineer about specimens, particularly pyrargyrites. He acknowledged that they sometimes encounter pockets of this rare silver mineral. But when quizzed about specimens, he admitted they were set aside and thrown into the melt to increase the silver content results when the ore was running a bit lean. It broke my heart to hear that.

Silver's biggest use is in the making of sterling silver, the alloy used to make tableware, jewelry, and such things as loving cups and awards. Early on, it was realized that pure silver was a poor metal for use in the making of jewelry. It is just too soft. The solution was to alloy it with another metal that would harden it, and the most commonly used alloying metal is copper.

The vast majority of today's lapidaries and jewelers depend on sterling silver for their livelihood. It is safe to say that sterling silver is the backbone of the jewelry industry. So it may interest you to know where the term "sterling" originated. I always thought it came from Great Britain, as in the pound sterling. But the term actually had its origins in Germany. When you think about it, that makes sense, since it was the German mines that yielded such huge amounts of silver during the Renaissance period.

It was the Hanseatic League, a group of North German cities founded in the 1200s and becoming an early monopoly, that gave us the term sterling. Silver coinage in Europe had slowly suffered a purposeful decrease in silver content as governments tried to control expenditures. The League made its own coins and these continued to maintain their silver content. These Hanseatic coins were called "easterlings" which easily became "sterling" in England.

In this country, the basic monetary unit is the dollar, and it, too, owes its name to silver. In Germany centuries ago, a silver coin was called a "joachimsthaler" after the silver mining in Joachimthal. The transition from thaler to dollar is an obvious one.

For silver to become useful as an industrial and jewelry metal, the alloying of silver required a standard. It was found that an alloy containing 7.5 percent copper would be suitably hard and scratch-resistant, without diminishing the beauty of silver or diminishing its value too much. Therefore, sterling silver, designated 0.925 sterling, means an alloy of 92.5 percent silver and 7.5 percent copper.

Mexican sterling silver is slightly different. The alloy contains more copper, so Mexican sterling is 0.875 sterling—87.5 percent silver and 12.5 percent copper. It may also interest you to know that nickel silver and German silver contain no silver at all! They just look like sterling silver.

While Mexico has been the major silver producer on the North American continent, there have been other significant sources. I've already mentioned the Michigan's Upper Peninsula. The state of Idaho has been the United States's biggest silver producer. The Comstock Lode in Nevada certainly yielded tons of the white metal, but that source is long since depleted. Idaho, on the other hand, is still a silver producer and has been since the 1800s. Not only that, but the silver mines of Idaho have given us some fantastic collector species, particularly spectacular pyromorphite.

Canada has had its heyday of silver production, as well. British Columbian mines have done their bit to enlarge the world's silver supply. Eastern Canada has also had its day in the sun—or should I say moon, since silver is often referred to as being lunar in appearance. The big strike in eastern Canada was at Cobalt, so named for the other valuable element found here. During the effort to supply timbers for railroad ties, two men found a silver outcrop and a rush was on. The silver was so abundant here that one 3-foot-wide vein was exposed at the surface and called the "silver sidewalk." Huge masses of silver, some weighing a ton or more, were found. Little fine specimen silver has survived from this location. Masses of calcite with beautifully patterned dendritic silver have sometimes been cut and polished to advantage. In a few cases, etching away the calcite has exposed nice, small wires of silver.

As I said, sterling silver is the mainstay of the jewelry industry today. It has been extremely important to the Native American jewelry industry, which has its roots in the early Spanish invasion. In those early days, the Native Americans, seeing the way Spaniards and the people of Mexico used silver to decorate both themselves and their horses, began making ornaments and decorative jewelry. They had no silver, so they used Spanish silver coins to make beads and conchos by hammering them. Gradually, they were taught to use heat to solder their work, and a very creative jewelry industry was born.

Now, extremely talented Native Americans create some of the most beautiful and highly praised jewelry to be seen. Necklaces, bracelets, rings and other pieces are made using every imaginable gem coupled with both gold and silver. Their work ranks among the finest produced anywhere in the world.

From its rare beginnings eons ago, silver has emerged as a metal of universal appeal, utilitarian function, and industrial importance, such that it is more important in the working and recreational world than is gold. Credit its physical and chemical properties, which make it everyone's indispensable precious metal. 💎

Fine silver dodecahedron crystals with minor copper from Michigan's Upper Peninsula (A.E. Seaman Museum, Houghton, Michigan).